THE SCIENCE TEACHER

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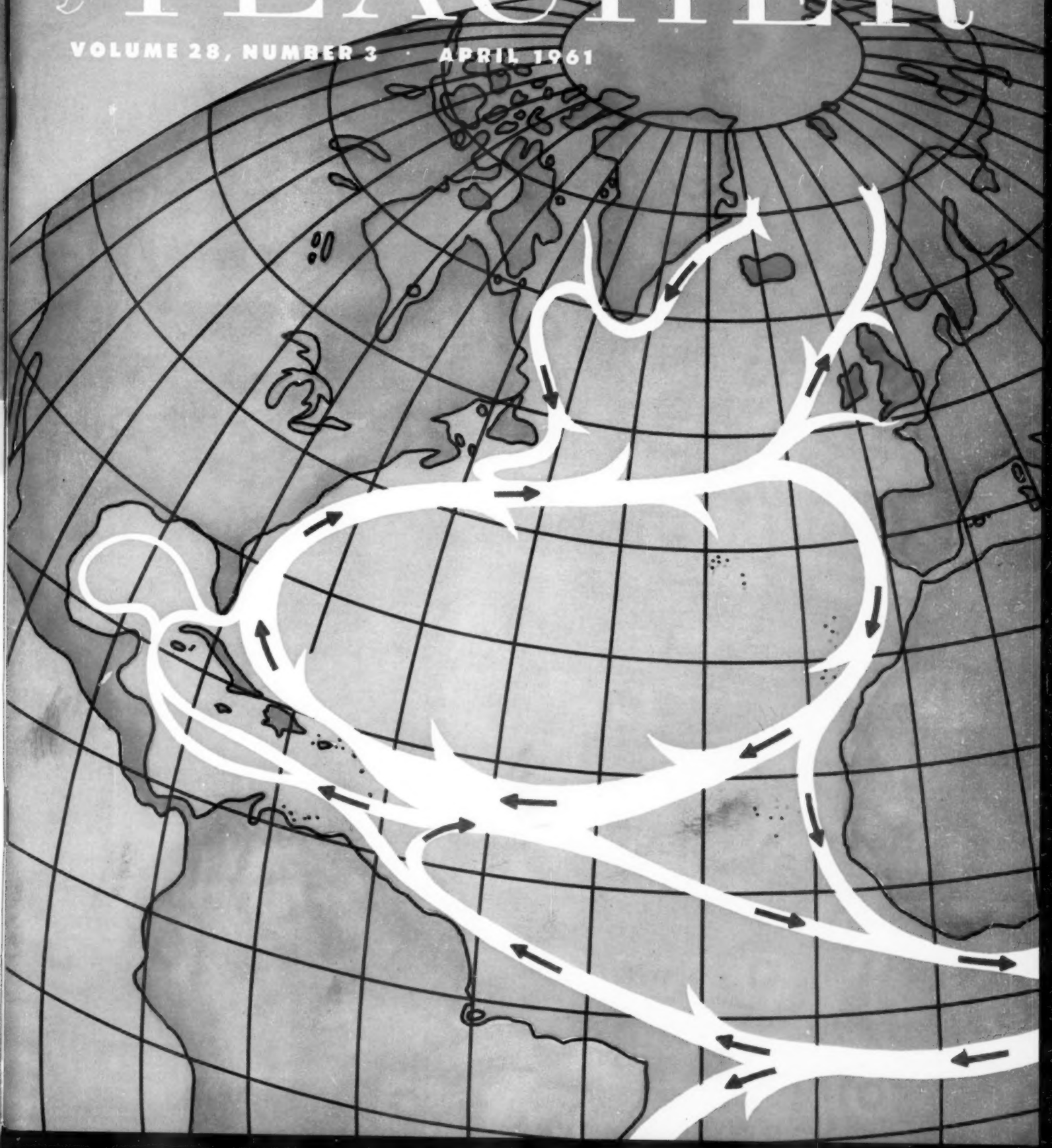

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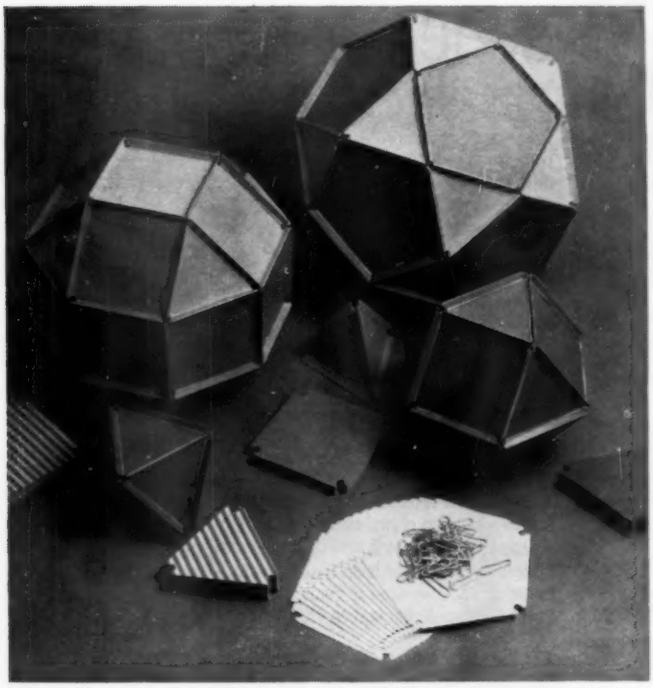

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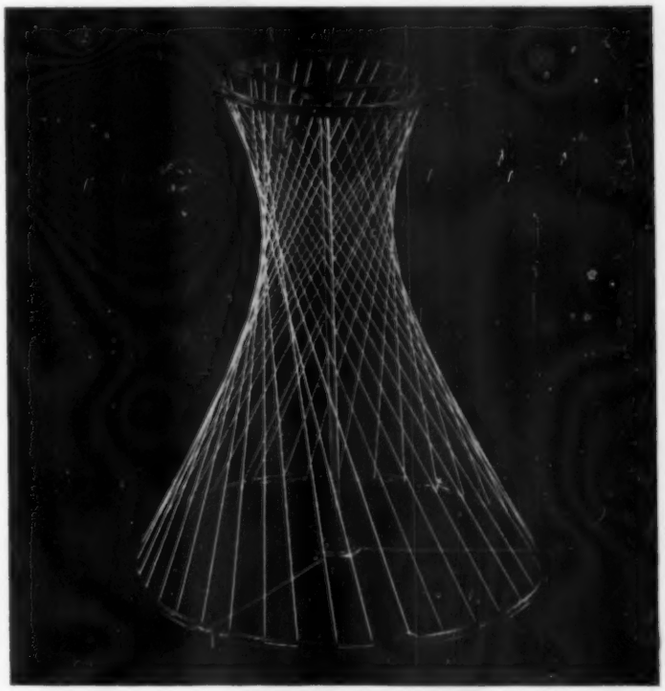

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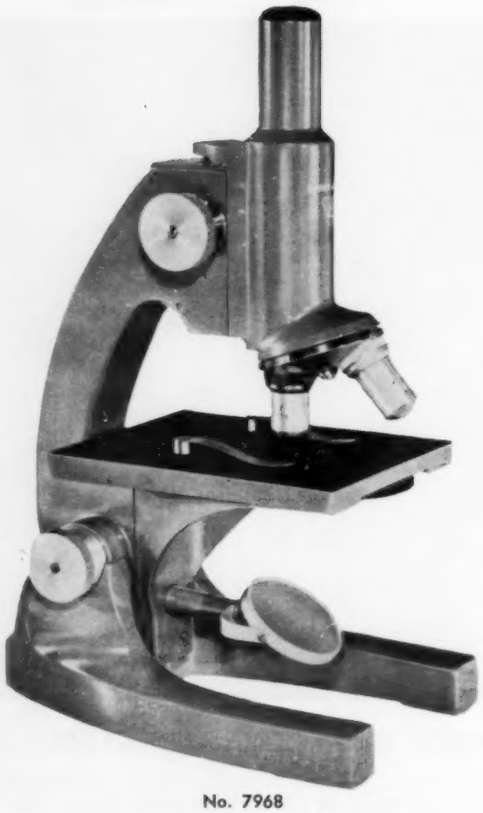

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The National Science Teachers Association is a department of the National Education Association and an affiliate of the American Association for the Advancement of Science. Established in 1895 as the NEA Department of Science Instruction and later expanded as the American Council of Science Teachers, it merged with the American Science Teachers Association and reorganized in 1944 to form the present Association.

Journal of the National Science Teachers Association
Volume 28, Number 3 • April 1961

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► Legislation: Now that President John F. Kennedy has sent his education message to Congress calling for massive federal assistance for elementary and secondary classroom construction and teachers' salaries, what are we in the crucible of the classroom going to do about it? Do we remain inactive and "twiddle our thumbs" while the NEA and other giant groups join in the perennial battle? We might express hope or even try prayer. But better still would be a deluge of well-worded telegrams and letters from the nation's 1.4 million classroom teachers—and it wouldn't hurt if somehow a few thousand school board members, parents, and civic leaders went to the wires too. You know best your own situation—inadequate salary, classes too large, schools crowded, facilities and aids for teaching woefully short, and—you continue. Commend President Kennedy for his bold, forthright stand. Encourage Secretary Ribicoff to "stick to his guns." Tell your Senators and your Representatives how you feel, and why, and that you want them to support the President in his drive to provide federal assistance for public schools, teachers, colleges and universities, and college students.

Senator Joseph S. Clark, writing in the February 18 issue of *Saturday Review* (p. 55) said: ". . . educators are not monks who take a vow of poverty, both for themselves and for the institutions they serve. They, too, are American citizens with the right, indeed the duty, to petition for redress of grievances and to indicate to their elected representatives how they would like those grievances redressed." You can do this in half an hour at the cost of two cartons of cigarettes. But, of course, if you oppose federal support, or if you don't care, history suggests that you can sit back confidently and smoke your cigarettes and "twiddle your thumbs."

► International: Maybe it's because NSTA is becoming more active in international activities or because I'm naturally a "stick-your-nose-in-other-people's-business guy," but it happened on a recent Washington-to-New York trip and I thought I should tell you about it because I believe that if our country is going to improve our deteriorated position of respect in the world, then each of us must be alert to every possibility to contribute as we meet more and more with citizens of other countries who come to visit us. Besides, I felt good about what I did—like having religion on Wednesday and Thursday, as well as Sunday.

It happened to a Spanish-speaking foursome in a Pennsylvania Railroad diner. They and I gave our orders at about the same time. Somehow I was served first and was halfway through my meal (and a slow eater I am) when the English-speaking member of the group touched my waiter and said, "We ordered some beer; could you bring it now?" To which was snapped (and I mean *snapped*) the reply, "Don't ask me; I'm not your waiter, and can't you see I'm busy?" Ten minutes later they were served—their food. Again the spokesman said, "We wanted beer first; could we have it right away?" And their waiter snapped, "If you want your beer first, you have to tell me; in this country we have our beer with our meals." But he brought it in due course.

By now old RHC was finished and with a "Pardon me" intruded. "I couldn't help seeing, and hearing, and being embarrassed. I feel I must apologize. Are you folks visiting here, and what is your country?"

"We are from Venezuela. We will be in the U. S. three months to learn how you do the printing business. It's all right; we don't know your customs yet."

"Well, this is not typical. You will be treated courteously, I'm sure, and I hope your visit is wonderful and helpful."

I went to my seat. (A dull, let-down ending? Perhaps; but I don't know how they fared in Erie, Keokuk, and Walla Walla, and so, of course, I can't tell you.)

► NSTA Budget: This is budget-making time in NSTA. Our budget committee and the Board of Directors have some tough problems to face and the decisions will not be easy; they may not be pleasant. Members of the Association, subscribers, and benefactors of its services are urged to share the responsibilities of planning for the year (or years) ahead.

We may have to face it—the fact that NSTA cannot indefinitely continue a program and budget the support for which from memberships and subscriptions amounts to only 25 per cent of the total. As of now, support through contributions of business-industry organizations has lagged—probably because of the general economic ill health—to about 30 per cent of prediction last June. There are other "short-of predictions" this year. The total now appears to be some $40,000. All of us are determined that we shall not again slip over the line to an operating deficit. To avoid this either we must increase our income or we must reduce our activities and services. Possibilities might be these.

An increase to $8 dues would produce about $15,000.

Convention registration of $5 would add another $3000.

"Tightening up" on committees and field services would save $10,000.

Addition of 5000 members would give a margin of $10,000.

Beyond these we must cut services and curtail programs. What is your advice? As a reminder, the present costs of providing *The Science Teacher*, Packets, a convention program, and a ballot add up to nearly ten dollars per member. What would you advocate if you were on the budget committee or the Board of Directors? Write to headquarters and let your voice be heard.

Robert H. Carleton

THE SCIENCE TEACHER

Volume 28, No. 3 — April 1961

The Journal of the National Science Teachers Association, published by the Association monthly except January, June, July, and August. Editorial and executive offices. 1201 Sixteenth Street, N.W., Washington 6, D. C. Of the membership dues (see listing below) $3 is for the Journal subscription. Single copies, $1. Copyright, 1961 by the National Science Teachers Association.

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Oceanographer, navigator, naturalist, archeologist, the famous inner-space explorer, Captain Jacques-Yves Cousteau, assumes the role of essay editor for THE SCIENCE TEACHER to introduce the challenging world of inner space described in the lead article which follows.

NATIONAL GEOGRAPHIC SOCIETY, WASHINGTON, D. C.

Captain Jacques-Yves Cousteau is currently leader of the National Geographic Society–Calypso Marine Archeological Expeditions.

WE hear much about outer space today. Perhaps by the time you read this, men will have actually entered outer space. This will be a significant scientific milestone. But hundreds of thousands are already exploring **inner space**, the depths of the oceans that cover nearly three-fourths of the surface of our planet. Explorations are being made by swimmers with automatic breathing apparatus in a realm forbidden except to a few helmet divers in the past. Now, divers are roaming weightlessly in three dimensions and have become the Inner Space Men of our century.

Free diving is a new tool of the fascinating science of oceanography which simply means unleashing the hidden secrets of the sea. It matters little which particular field of science a student enters—virtually all disciplines are applied to a study of the oceans, beginning with physics, chemistry, and biology, and finally other areas including archeology. Underwater archeology is a rapidly growing activity which tells us more about ancient commerce than was learned from land sources and opens up new areas of conjecture.

By now, it is a banal thing to say oceanic exploration is a vital necessity for the continued sustenance of the human race. All intelligent people recognize its importance. The problem today, it seems to me, is to quicken and widen our exploration and exploitation of the riches of the sea. We are only at the beginning stage of rational fishing, experiments in aquaculture, and many other unpredictable experiences related to science. Similarly, we have only begun to learn the basic geophysical data that are buried in the water masses.

Our planet has a unique advantage over the others in the cosmos in that this mantle of water from which the Kingdom of Nature came is a part of our earth and belongs to us. The sea has all the fresh water man will ever want, if we work out ways to convert it from salt or for other purposes yet unknown. It contains all the elements we shall ever need and all the sources of power, if we learn to use them.

Oceanography lacks oceanographers.

NATIONAL GEOGRAPHIC SOCIETY

The famous amphibious explorer and coinventor of the Aqua-Lung takes pride in his archeological crews that explore the ocean's depths for new knowledge. The Cousteau projects are sponsored by the National Geographic Society of Washington, D. C.

The present leaders of the science are largely converted specialists from the tributary fields, and there are not enough of them, let alone people brought up from the age of career decision to be oceanographers. Oceanographers begin to be developed, or show first interest in this area, at the graduate level; but they should be guided into it much earlier in science education. There is certainly no lack of interest on the part of youngsters. They are taking to the water in vast numbers. Their curiosity is keen about oceanic phenomena at the beach-toddling age. The free-diving sport has unlocked much of the continental shelf to human exploration. The young underwater explorer is highly receptive to teaching that will orient him to the marvelous new world he has entered. I will go so far as to say the teacher has things to learn from this underwater generation, if the science syllabus should bring together teaching craft and student enthusiasm for studies in this area.

Not only does oceanography demand teaching in pure science, but it calls for engineering skills. Instruments for studying the sea are now largely electronic and there is a shortage of oceanographic electronicians. They can be encouraged to pursue the technical curricula with the participation, one hopes, of the basic science faculty.

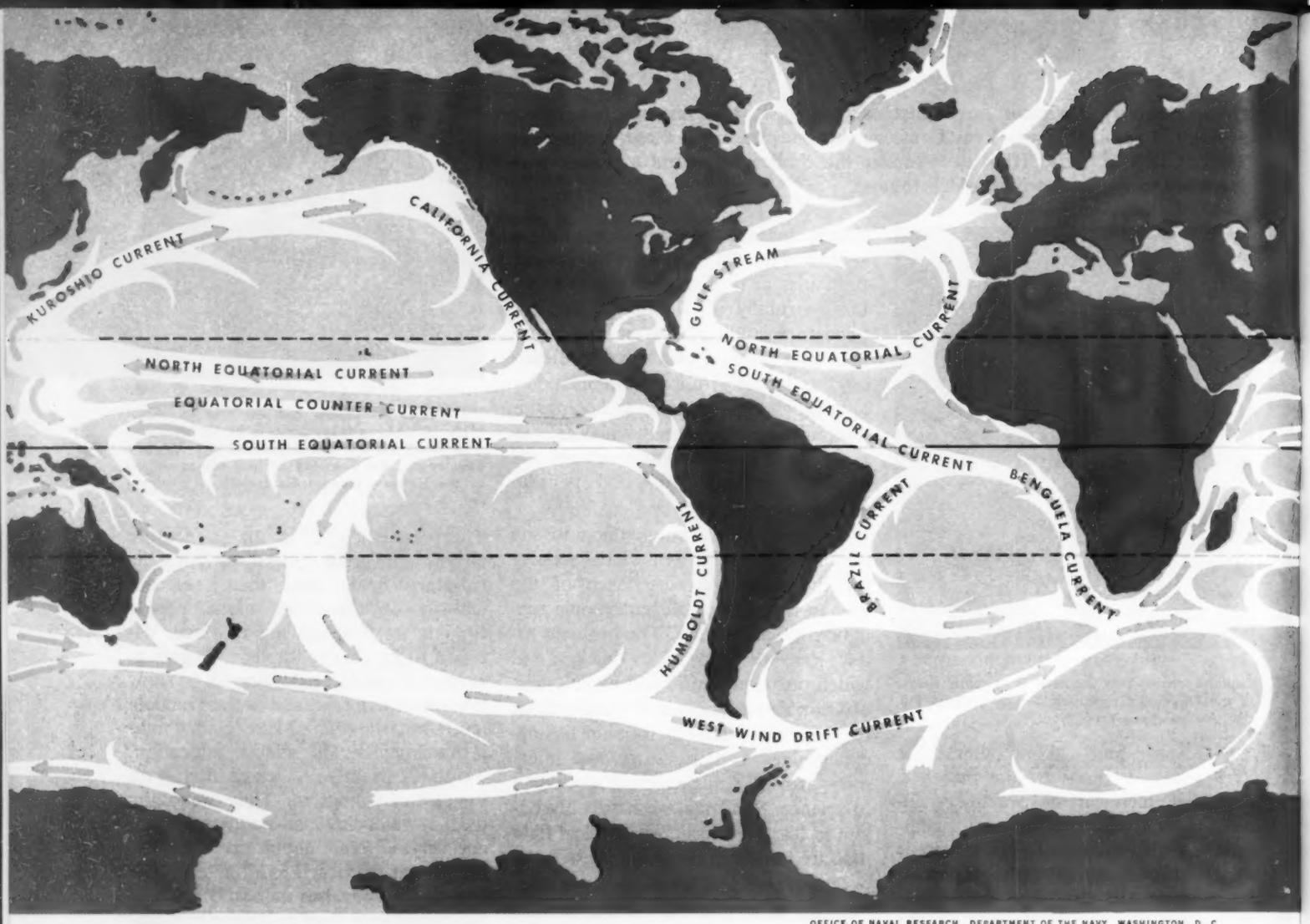
The ocean is a vast field laboratory and the last great unknown region of the earth. It is waiting for the inquisitive, the adventurous, and the inventive.

JACQUES-YVES COUSTEAU
Director,
Musée Océanographique de Monaco
Monte Carlo

THIS MONTH'S COVER . . .

The major current system of the North Atlantic Ocean is vividly demonstrated (although exact conditions are not represented) in the artist's conception of ocean currents discussed in the lead article.

Flowing along the coast of the United States before turning east and branching to warm the shores of Great Britain and Norway is the Gulf Stream. The great streams flowing between Africa and South America are the North Equatorial and South Equatorial Currents. The Sargasso Sea lies surrounded by the great ocean currents as shown in the center. Reprinted by permission of the U. S. Navy.



OFFICE OF NAVAL RESEARCH, DEPARTMENT OF THE NAVY, WASHINGTON, D. C.

The Challenge of Inner Space

By FEENAN D. JENNINGS

Oceanographer, Office of Naval Research, Department of the Navy, Washington, D. C.

TO date, most of the earth above the oceans has been explored, but very little is known of what lies beneath the surface of the vast ocean waters, the inner space. To relate what *is* known, it is convenient to look at the oceans from the viewpoint of the sciences that are used in its study.

In reality, oceanography is not a true science, but rather the application of physics, chemistry, biology, and geology to the study of the oceans, its bottom shoreline, and the air-sea boundary. In such studies, the oceanographer uses all of the conventional scientific tools such as models, computers, a startling variety of instruments for measuring and sampling, and in addition, requires the use of a research ship.

A research ship is a floating laboratory from which the oceanographer must perform many tasks. From its decks he must collect samples of sea water from all depths in the oceans, sample the bottom and photograph it, and plot the ocean currents at the surface and at depths. In its laboratories, he must perform chemical and biological analyses on many of the samples collected and make a myriad of physical measurements of the oceanic environment. The capital to operate these research ships makes oceanography one of the most costly fields of study; second only to space and nuclear physics.

In spite of the expense, our eleven oceanographic institutions presently operate sixteen ocean-going research vessels and fourteen smaller ships for near-shore studies. These ships are necessary because the oceans, which cover 70 per cent of the earth's surface, occupy the total volume of 324,000,000 cubic miles.

During 1959 and 1960, the Committee on Oceanography of the National Academy of Sciences issued a

twelve-chapter report entitled "Oceanography 1960 to 1970."[1] In the report, it was pointed out that the oceanographic research and surveying effort of the United States would have to be doubled within this decade, to meet the country's needs for national defense, food resources, and the many other uses which are made of the oceans.

In its deliberations, the Committee found that one of the limiting factors in expanding the nation's oceanographic program is the shortage of adequately trained personnel.

To determine what the Federal Government could do, under existing policies, to increase the number of students in oceanography, the National Science Foundation called a conference on "Research and Education in the Marine Sciences" in Washington, D. C., during October of 1960. Attending the meeting were representatives from five departments of the Federal Government and twenty-two educators from almost every university that teaches marine science. In general, the meeting disclosed that sufficient government aid *is* available to students of oceanography, but at the present time, there are not enough applicants to fulfill the requirements of the expanding oceanographic effort in research and experimentation.

One of the reasons for this lack of students is the fact that most oceanographic institutions do not accept students until after they have graduated from college with a degree in one of the sciences. Another is the limited number of universities that teach oceanography. Still another is the fact that most people in the United States are not even aware that oceanographers exist, although that situation is now changing rapidly.

Physical Oceanography

The physical oceanographer is interested primarily in the motions of the sea and in its physical properties. He has learned much about circulation of the oceans. In general, he has discovered and named the major ocean currents of the world. These are shown on page 6. They are called wind-driven currents because they are kept in motion by the drag of the trade winds which blow toward the west at the equator, and the prevailing westerlies which blow toward the east in the temperate latitudes.

Although it is true that these currents are kept in motion by the winds, there are two other factors which have an effect on them. One of these is the friction between particles of water; the other is the *Coriolis Force* which causes a moving object to be deflected because of the earth's rotation. In the Northern Hemisphere this deflection is to the right, and in the Southern Hemisphere it is found to the left. (See page 49.)

The Pacific Ocean may be used as an example of how these factors combine to give our current systems. In the trade wind region, the westward blowing winds try to drag the water toward the west. The friction between water particles causes the water to pile up on the north edge of the wind. As the water flows downhill to the south, it is deflected toward the right by *Coriolis Force,* and flows west. Essentially, there is a mound of water, about three or four feet high, in the middle of the ocean around which the ocean currents will always continue to flow.

The best known of the major ocean currents is the Gulf Stream which flows northward along the East Coast of the United States at a rate of more than fifty miles a day and then turns eastward and divides into several branches. This current, forty miles wide and 3000 feet deep, transports over 2000 times as much water as the Mississippi River.

The research vessel, *Chain,* is a 1900-ton ship, one of the larger, modern type used by oceanographers.
R. MUNNS, WOODS HOLE, MASS.

[1] Requests for individual copies of the reports may be addressed to the Committee on Oceanography, National Academy of Sciences-National Research Council, 2101 Constitution Ave., N.W., Washington 25, D. C. (See Professional Reading, page 64.)

The least known is the Cromwell Current which was discovered only eight years ago beneath the South Equatorial Current in the Pacific and which was not explored until 1958. The reason it went so long undiscovered is because it does not appear at the surface. Its core is at a depth of about 300 feet and it extends from 100 feet to 1000 feet. It is over 200 miles wide and flows eastward along the equator for a distance of 3500 miles transporting almost half as much water as the Gulf Stream normally carries.

In addition to the many large currents on the drawing, the oceans are continuously being mixed by the slow exchange of water between the surface and the ocean depths. At high latitudes, the surface waters are cooled by the cold air over the oceans, and the resulting increase in density causes the water to sink. As it sinks, it flows toward the equator from both the north and south and is gradually warmed as it mixes with other water masses. This type of vertical mixing is known as the slow overturn of the oceans. From radioactivity measurements, it is estimated that from the time a particle of water sinks near Antarctica until it appears again near the equator, several thousand years will have passed.

Because of this continuous mixing by both currents and overturn, the oceans act as a giant global thermostat to help regulate the climate of the world. The currents which flow toward the equator bring cold water to the warm tropical regions while currents like the Gulf Stream carry the warm water toward the colder latitudes. Great Britain, which is bathed by one branch of the Gulf Stream, has an average temperature thirty-five degrees warmer than would normally be expected at that latitude, as shown by recent records.

The wave motions in the oceans are also the concern of the physical oceanographer. Although tides are not usually spoken of as waves, they do have wave-like characteristics with periods which correspond to lunar cycles. Ocean tides are caused by two effects. The earth and moon rotate about a common point and the centrifugal force due to this rotation is directed away from the moon. The force due to attraction of the moon's gravity is just the opposite. The balance of these two forces is strong enough to raise the water surface fourteen inches on each side of the earth in line with the moon. Similar calculations for the earth-sun combination show that the tidal forces caused by the sun are about half those caused by the moon.

It is well known that many of the tides observed along coast lines are much greater than the fourteen inches calculated here. This is because the water tends to move horizontally under the tidal influences and piles up along the coasts. This normal pile-up is often enhanced when water becomes funneled into narrow channels from larger bays or harbors. In the Bay of Fundy, this funneling, combined with the shape of the bay, results in a tidal range as great as fifty feet, the highest in the world known to be recorded.

Another type of wave is that generated by underwater disturbances such as landslides caused by earthquakes. Although these waves are often referred to as tidal waves, they are not caused by tides. The scientific term for them is Tsunamis. These seismic sea waves, which have periods varying between fifteen and sixty minutes, travel across the oceans at speeds up to 600 miles per hour. In the open ocean, the wave height is quite small, usually less than five or ten feet. Because of their extremely long wave length, they have no effect on ships at sea and in fact, are not even observed. Upon reaching shore, the wave is subject to refraction by the bottom, and to funneling as in the case of tides. Under these conditions, the wave can build up to great heights and cause enormous damage and loss of life.

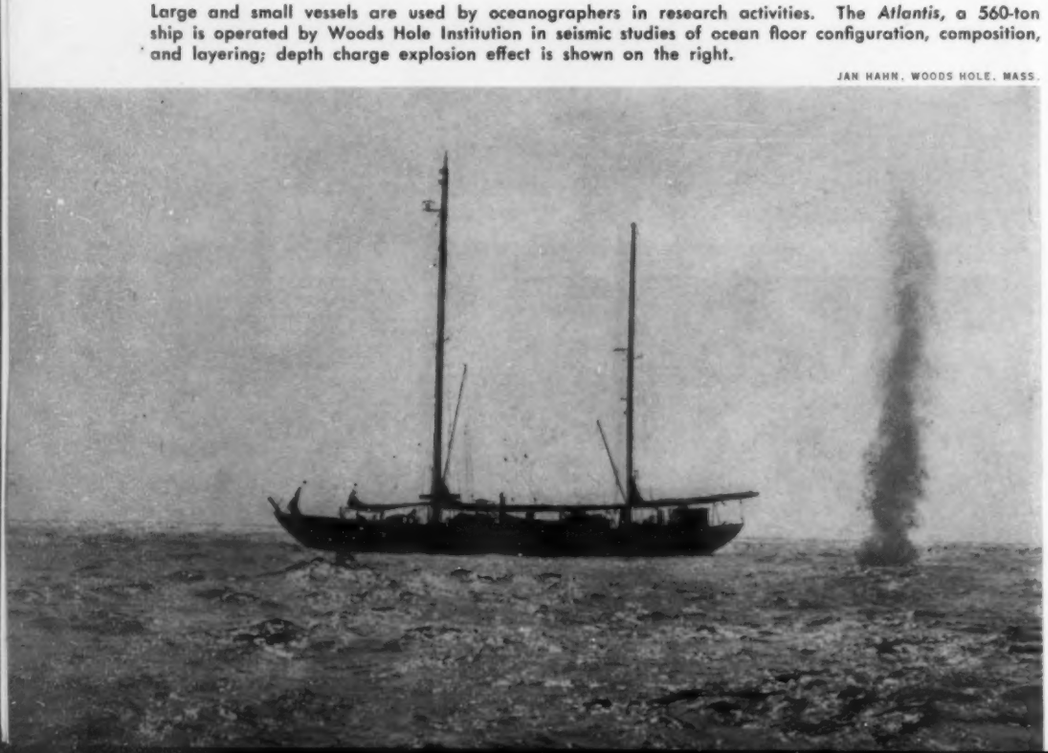
An outstanding example is the series of Tsunamis that accompanied the eruption of the volcano, Krakatao, in Sunda Strait on August 26 and 27, 1883. The highest of these waves caused great devastation on some of the East Indian Islands where more than 36,000 persons lost their lives and where waves in certain localities must have reached a height of 115 feet.

The most common waves in the ocean are wind waves. These are so called because they are generated by the wind as it blows on the surface of the water. Essentially, there are three factors involved in the generation of waves by wind. The first is wind velocity in which the height of the waves increase with an increase in the wind velocity. The second is the duration of time during which the wind blows. The longer the time, the higher the wave for a given wind velocity. The third is the fetch, which is the distance over which the wind blows on the surface. The longer the fetch, the higher the wave. Naturally, there is a limit to the wave height that can be generated by this process, but in the center of a severe storm, wave heights of fifty to sixty feet are not uncommon.

As the waves generated in the storm radiate out from the storm center and leave the influence of the wind, they are termed swells. These swells, if uninterrupted by islands, opposing surface winds or opposing swell, travel the

Large and small vessels are used by oceanographers in research activities. The *Atlantis*, a 560-ton ship is operated by Woods Hole Institution in seismic studies of ocean floor configuration, composition, and layering; depth charge explosion effect is shown on the right.

JAN HAHN, WOODS HOLE, MASS.



length and breadth of the ocean. As they travel, their shape is altered. They become flatter, their wave length becomes longer, and their period increases.

It is worth noting here that these waves result in very little transport of water. Although the water particles within the wave are in motion, they essentially describe a circular orbit as the wave passes, and only the fact that the orbit advances a slight amount with each passing wave results in any mass transport of the water at all.

As the wave approaches shallow water, the drag of the bottom on the water particles causes the circular orbit to become elliptical, and when the water becomes shallow enough, the drag becomes so great that the water particles in the top of the wave overtake those near the bottom and the wave breaks, forming surf. It is also this bottom friction that causes the refraction of waves. For example, a wave advancing on an underwater ridge which is perpendicular to the shore line is slowed down by the bottom friction on top of the ridge while the water on the sides of the ridge maintains its original speed. This causes the energy of the wave to converge above the ridge and results in much higher surf at that point on the beach. In the case of a submarine valley, the wave diverges.

The physical oceanographer is interested in many of the oceanic phenomena aside from those just described. Some of these are underwater acoustics, which is of extreme interest to the Navy in its Anti-Submarine Warfare Program; the effect of the oceanic environment on transmission of light and other electromagnetic radiation; and the distribution of temperature and salinity and its effect on density.

THE UNIVERSITY OF CALIFORNIA, LA JOLLA, CALIF.

Engineer Maxwell Silverman, pushes overboard a 200-pound charge of TNT from shooting table of research vessel. An explosive charge originates waves which travel through the sea floor and are picked up by another ship.

Marine Chemistry

The chemical oceanographer is primarily interested in the chemical composition of sea water, the distribution of those constituents, both horizontally and vertically, and the part that the chemicals play in the biological cycle of the oceans. In addition to hydrogen and oxygen, which make up the water itself, and the rare gases such as neon, helium, and argon, there are 44 known elements in sea water. Because the composition is so complex, the usual methods for the determination of the chemical concentrations of the elements must be used with great care and in some cases cannot be used at all because of the interference from other similar elements.

In 1884, an English oceanographer by the name of Dittmar determined the composition of 77 sea water samples which were gathered from all of the oceans of the world and determined that "regardless of the absolute concentration of total solids, the ratios between the more abundant substances are virtually constant." [2] On the basis of these determinations, oceanographers since that time have been able to determine the total salt content (salinity) by determining only one constituent. This constituent is the halide group made up of chloride, bromide, and iodide. This value is called chlorinity. The relationship between chlorinity and salinity is expressed by the following empirical equation:

$$\text{Salinity} = 0.03 + 1.805 \times \text{chlorinity}$$

It is very important to know the salinity because the classical method of calculating currents within the oceans is based on the density structure of the water column. The density is determined from the temperature, pressure, and salinity.

In recent years, oceanographers have developed a new technique for measuring salinity. It is based on the conductivity of the sea water. This method is much more precise and much more convenient to use aboard ship than the chemical titration method in which chlorinity is determined. In fact, the determination is so sensitive that the work performed by Dittmar seventy-six years ago is now being repeated in order to improve the knowledge of the relationship among conductivity, chlorinity, and salinity.

It will be shown later that the ocean is full of plant life that requires nutrients in the same manner as terrestrial plants. The marine chemist plays a large role in the determination of the concentration of these nutrients and their effects on the growth of plants in the ocean. The cycles of carbon, nitrogen, phosphorus, and several other of the nutrients have been traced from the sea water through the cycle of the plant life and back into the sea water again as the plants grow, then die, and decay.

Several of the elements in sea water are present in quantities concentrated enough to make their commercial extraction worthwhile. Among these are bromine and magnesium, and it now seems probable that with improved distillation equipment, the production of

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[2] H. U. Sverdrup, M. W. Johnson, and R. H. Fleming. *The Oceans*. Prentice-Hall, Inc., New York. 1946. 1088p.

S. BOLTZ, WOODS HOLE, MASS.

Determinations of oxygen concentration are made by chemical titration studies in the laboratory aboard the *Atlantis*. Evaluations and data are then sent to inland laboratories.

fresh water from sea water will soon be commercially feasible.

The application of radiochemistry to the study of the oceans is increasing rapidly. Radiochemists have been able to determine the overturn time of the water in the ocean basins and the rate at which sediments are deposited on the bottom of the deep oceans. They are presently beginning to study physical processes by the use of radioactive tracers and the concentration of the extremely dilute elements by neutron activation analysis.

Marine Biology

As was stated earlier, the ocean contains a great amount of plant life, but the plants there have unique shapes and sizes which permit them to grow in the ocean environment. Since plants require sunlight, and in the ocean sunlight does not penetrate to depths greater than 300 or 400 feet, the plants must remain in the upper layers in order to obtain sufficient sunlight for their photosynthesis. Because living matter is heavier than pure water, having a density range between 1.02 and 1.06, the plants had to adapt in some way to maintain themselves in the sunlit layers. One of the major adaptions is their very small size.

Plants in the ocean, except for rather large kelp near the coast, are microscopic in size in order to keep their place in the sun. In the case of a sphere, the weight of an object varies as the cube, and the surface area as the square of the radius. Since the drag exerted on a sphere depends on the surface area, the smaller the plant becomes, the larger the ratio of the drag becomes. These microscopic plants are called *phytoplankton.*

In addition to being very small, they have taken on special structures, shapes, or other means to help them remain near the surface. Some of the methods, in addition to the small size which plants use for flotation, are exemplified by diatoms, which may be shaped like discs or needles or threads and contain oil to lessen the specific gravity of the plant, and dinoflagellates that contain two tiny whip-like flagella which by almost constant ungellation provide a means of feeble locomotion.

Another similarity exists between the land and the oceans in that there are animals that graze on the phytoplankton. These tiny animals, or zooplankton as they are called, are solely dependent upon the phytoplankton for food and can only grow in waters that contain sufficient nutrients for the plants. Because of this, there are great areas in the oceans which correspond to our deserts. In these regions the nutrients have all been used up and the waters are not mixed enough to renew them. On the other hand, there are areas in the oceans which are extremely fertile. These occur along coast lines where upwelling brings the nutrients from the deep waters and along the boundaries of currents where the mixing process brings up the nutrients.

The zooplankton are consumed by filter feeding fish which are slightly larger than the zooplankton, and these in turn are eaten by larger fish in a veritable chain. It has been estimated that 1000 pounds of phytoplankton are required to produce one pound of game fish such as tuna or salmon. Commercial fishing in this country is a large industry and, to learn more about the habits of fish, it supports much of the research that biologists carry out.

Because of the concentration of plants near the surface of the ocean, most of the other forms of life also live there. However, there are many forms that burrow in the sediments and obtain their food by filtering out the detritus that rains down from the waters above. In addition, there are many fish that live deep in the ocean waters and who have adapted to the cold, dark, high-pressure environment. These fish very often supply their own light by the use of chemical bioluminescence, but the major adaption they have made is the result of the scarcity of food at these great depths. Almost all of these fish have an extraordinarily large mouth in proportion to the size of their body. This enables them to devour other organisms which are larger than they and which may supply sufficient food until another victim is found.

The marine biologist does not confine himself strictly to the study of marine organisms from a fishery's point of view. He must study such organisms as barnacles and boring animals that destroy piers and shore facilities; he must understand what it is that makes some fish poisonous to man; and he even uses the distribution of plankton to study the physical motions of the ocean water, such as currents or the slow movement of water masses. One further note is worth mentioning. It is often thought that the oceans are very quiet, particularly as one goes deeper. This is not factual. Biologists have determined that most fish make noise and that during certain seasons of the year, the amount of noise produced can be considerable.

In relation to the biologist, the marine geologist had an advantage because of early access to the shore lines.

Marine Geology

Unlike studies of beaches and shallow water areas, the knowledge required of the deeper oceans had to await development of the winch and steel cable era and, even more so, the use of underwater acoustics as a measurement of underwater depths. Aside from the shoreline, the bottom of the ocean is divided into three areas. The first of these is the continental shelf which is relatively shallow, about 700 feet in depth. Off the East Coast of the United States the shelf is very well defined, while off the West Coast, it is so irregular that it is referred to as the continental border land. Beyond the shelf area the bottom slopes gently downward in the area known as the Continental Slope until it reaches the third area, the deep ocean basins with depths between about 11,000 and 20,000 feet. Although the broad expanses of the ocean basins are fairly flat, they are interrupted by mountain ranges which extend from depths of 25,000 feet to the surface of the ocean and by trenches and deeps in which the depths are as great as 36,000 feet.

On the shore lines, the marine geologist is concerned with the erosion due to the wave action. He is also concerned with the movement of sediments along the coast. For example, in designing a breakwater which juts out from the coast, he must know the amount of sand that is being transferred along the beach by the combination of wave action and long-shore currents. He must know this in order to be sure that the purpose for which he is building his breakwater is not nullified by the build-up of sand as a result of his work.

From his explorations of the continental shelves, he has determined that it is quite possible that extensive oil fields lie beneath the bottom and that the tapping of this supply awaits only the development of the technology.

The deep ocean basins themselves are covered with thousands of feet of sediment which have rained down over periods of billions of years from the decay of plants and animals, fine dust which has blown off the continents, and meteoric dust from outer space. Radiochemical studies of sediments indicate that the rate of deposition of these deep sea sediments takes place at the rate of about one-half inch per thousand years.

The instrument used to determine the depth of the water is the Echo Sounder. In this instrument a short burst of sound is produced at the bottom of the ship, and the length of time taken for the sound to reach the bottom and be reflected back to the ship again is a measure of the distance. Using the Echo Sounder, a ship can obtain a continuous trace of the water depth as it travels across the ocean. On the basis of hundreds of thousands of such records, bottom topographic sheets are compiled so that we presently know the general shape of the ocean bottom and most of the mountains and trenches.

In addition to his interest in the shape of the bottom, the marine geologist is interested in its structure. The method of determining this structure is very similar to that used in the Echo Sounder except that the sound generated by the ship is much larger and the reflections occur not only from the bottom, but from the various layers of

SCRIPPS INSTITUTION OF OCEANOGRAPHY, LA JOLLA, CALIF.

On the research vessel, *Argo*, August H. Giobbi works in the laboratory with Precision Depth Recorder (left) and an *Edo* Echo Sounder in center background.

Navy Oceanographer explores deck of sunken ship on ocean bottom with camera. Note accumulations around ship frame. These provide considerable data for study.

WOODS HOLE, MASS.

Classification and separation of biological specimen begin immediately after recovery by scientists from the ocean.

sediments and rocks beneath the bottom. Using these tools, it has been determined that the thickness of sediments in the deep ocean basins varies between one-half and one mile. It has also been determined that the earth's mantle is only 30,000 feet beneath the surface of the ocean. This fact has led the organizers of the *Mohole* Project, which is a plan to drill a hole to sample the earth's mantle, to attempt the drilling from a ship in the deep ocean.

A review of our knowledge of the oceans by this method is not entirely satisfactory, because the application of the basic sciences overlap to such a large extent. The biologist, in his work, must take into consideration each of the other fields in his studies of organisms. The chemist cannot consider the chemistry of sea water alone, but must evaluate what effect the physics, biology, and geology of the oceans have on his measurements. Nevertheless, such a treatment does permit a fairly coherent presentation of what we know about the oceans.

When it is realized that only the surface of what we know has been covered, one may well ask why do we now emphasize the fact that oceanography is in its infancy and why does the National Academy of Sciences Committee insist that our oceanographic effort must be doubled. A few examples of what we do not know and what we need to know may serve to show how insufficient our present knowledge is and will point up the need for more studies.

In national defense, our efforts to detect enemy submarines by acoustic methods are hampered by the fact that the sound signals produced by our sonar equipment are refracted by density changes, absorbed by chemicals, scattered or absorbed by the bottom, and masked by biologically produced sounds. We do not know enough about any of these parameters to predict what our acoustic signals will do in any given location or at any time. In addition, we must learn more about the oceans in order to efficiently operate our own submarines, surface ships, and aircraft and to carry out amphibious operations for any need.

JAN HAHN, WOODS HOLE, MASS.

A snake mackerel, formerly thought to be rare, is caught by Frank J. Mather of the Woods Hole Institution. Fish are caught by trolling at the surface from research vessels in the open sea.

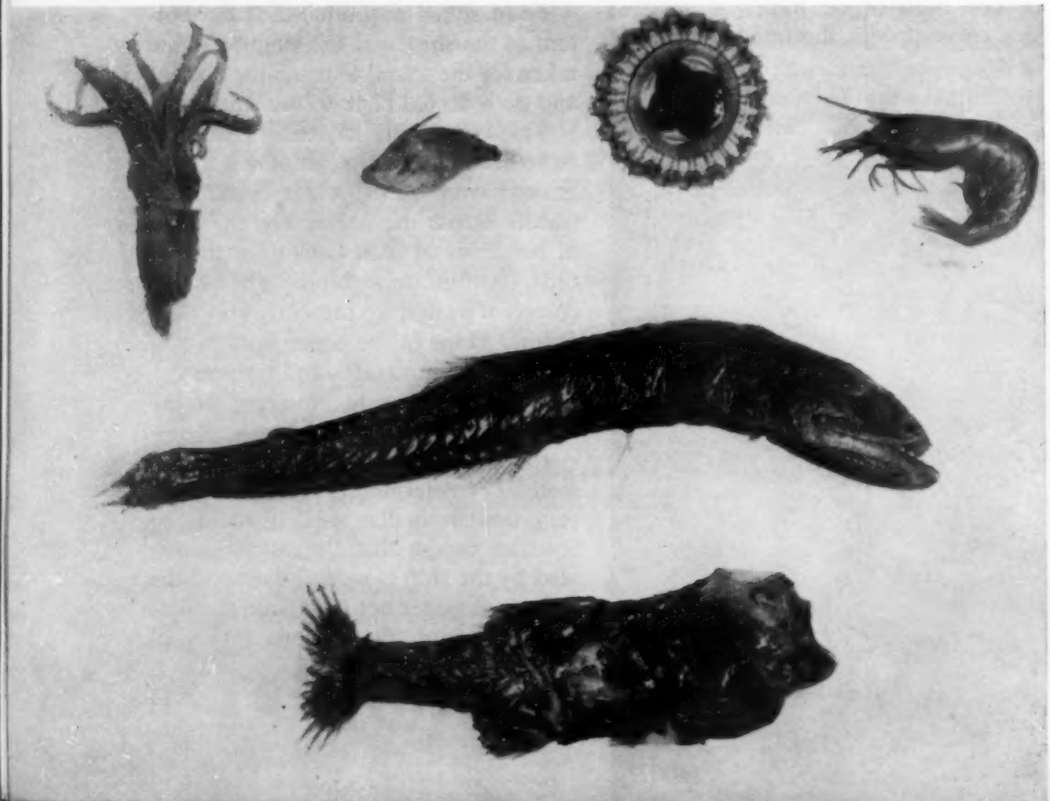
Rapid advances in the use of atomic energy for peaceful purposes have resulted in vast quantities of radioactive wastes. It is highly desirable to dispose of these wastes in the oceans, but our limited knowledge of the environment restricts the use of the oceans as an atomic-dumping ground.

As our scientific achievements develop and the demands of the populations of the world increase, we will ultimately turn to the sea to augment our food supply. At the present time, we can do very little about predicting where fish may be caught and we can do nothing about the supply of nutrients for the food cycle in the oceans. Ultimately, it is hoped that we may find some of the answers to questions of this type by extensive research and marine biology and chemical oceanography.

These are the challenges of **inner space.** We must apply all of our scientific knowledge to the solutions of problems in the oceans which hamper our national defenses and economic growth. The oceans are a vast untapped source of minerals, power, fresh water, and food. These are available to all who have the courage and intelligence to develop them.

The variety of sea life, some seldom seen by man, is disclosed from this dredge haul from 300 fathoms.

WOODS HOLE OCEANOGRAPHIC INSTITUTION.



NOTE: See availability of color slides on oceanography under Audio-visual aids on page 65.

A GIANT RADIO HIGHWAY IS PERFECTED FOR TELEPHONY

A radio relay system operating at 6 billion cycles per second and able to transmit 11,000 voices on a single beam of microwaves—several times as many as any previous system—has been developed at Bell Laboratories. Utilizing the assigned frequency band with unprecedented efficiency, this new, heavy-traffic system was made possible by the development and application of new technology by Bell Laboratories engineers and scientists.

For example, they arranged for the waves in adjacent channels to be polarized 90 degrees apart, thus cutting down interference between channels and permitting the transmission of many more telephone conversations in the same frequency space. They developed ferrite isolators to suppress interfering wave reflections in the waveguide circuits; and a new traveling wave tube that has ten times the power handling capacity of previous amplifiers and provides uniform and almost distortionless amplification of FM signals. They devised and applied a new high-speed diode switching system which instantly switches service to a protection channel when trouble threatens.

To transmit and receive the waves, the engineers applied their invention, the horn-reflector antenna. Elsewhere, this versatile antenna type is brilliantly aiding space communication research in the reception of radio signals from satellites. For radio relay, a single horn-reflector antenna can efficiently handle both polarizations of the 6000 megacycle waves of the new system; at the same time it can handle 4000 and 11,000 megacycle waves used for existing radio relay systems. Thus it enables all three systems to share economically the same radio towers and routes.

Produced by the Bell System's manufacturing unit, Western Electric, the new system is now in operation between Denver and Salt Lake City, and will gradually be extended from coast to coast. This new advance in radio technology is another example of how Bell Telephone Laboratories works to improve your Bell communication services.

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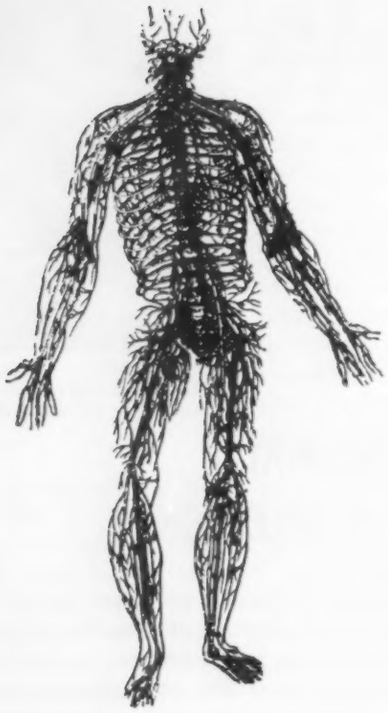

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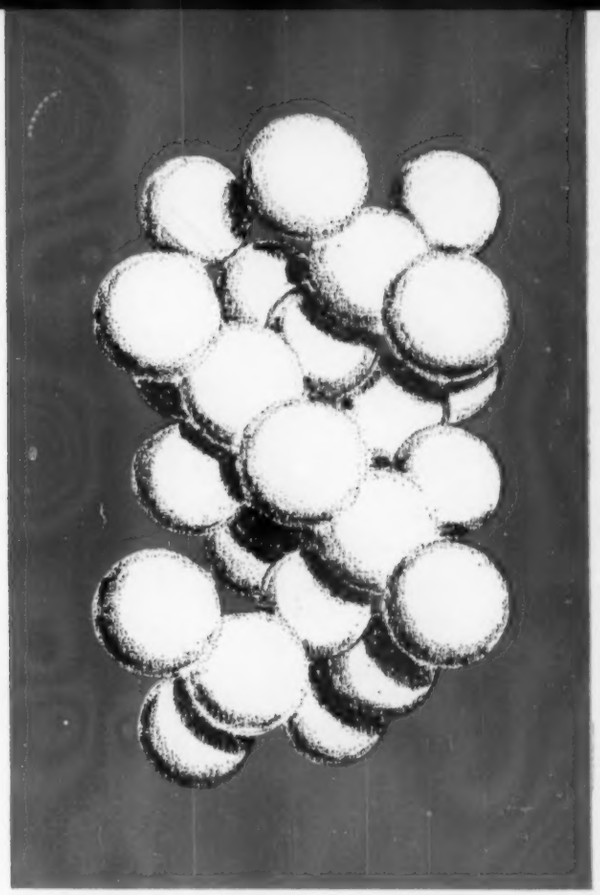
THE NEW CHEMISTRY



By ALFRED B. GARRETT

Chairman, Department of Chemistry, The Ohio State University, Columbus, Ohio

TWO major national studies and numerous local ones are now in process on the general topic "What should be the first course in chemistry today?" The two major studies, financed by the National Science Foundation, are a part of the program of the foundation to restudy each of the major areas of science. One study, known as the Chemical Bond Approach (CBA), will be completed at Earlham College, Richmond, Indiana. It will be directed by Laurence E. Strong of Earlham College and M. Kent Wilson of Tufts University, Medford, Massachusetts.[1]

The second study, being prepared at Harvey Mudd College, Claremont, California, is the Chemical Education Material Study (CHEM Study), under the chairmanship of Glenn T. Seaborg, University of California, Berkeley. It will be directed by Arthur Campbell of Harvey Mudd College.[2]

At the beginning of the NSF support, it was made clear by the project directors that the objective of each program was to make a careful and complete restudy of the chemistry program; it was not to be a patchwork job on the present curriculum. The pace setters for these studies were the physicists who developed the Physical Science Study Committee program under the direction of Professors Zacharias and Friedman at the Massachusetts Institute of Technology, Cambridge. All important facets of the teaching of the first course in chemistry were to be explored: the syllabus, the laboratory problems, the demonstration problems, the visual aids, the textual materials, the supplementary reading, and perhaps the examinations.

The Chemical Bond Approach Study

The content of the syllabus for this study originated in a summer institute of high school and college teachers at Reed College, Portland, Oregon, in 1957. The concern of the group was the solution of the problem of duplication between chemistry taught in high school and in the first-year college course. As a solution the proposal was made that the high school course content could be built around a theme; the theme selected was the "Chemical Bond." This seemed to be a reasonable solution since it is now possible to explain the properties of compounds in terms of the types of bonds that are present. Hence the syllabus was built around the topics atomic structure, chemical bonds, properties, and types of reactions. This gives a wealth of exciting subject matter.

The syllabus is still in process of revision; the following is a listing of the chapters and experiments in their present edition.

Table of Contents of Text

1. The Science of Chemical Change.
2. Some Typical Chemical Reactions.
3. Electrons, Protons, and Chemicals.
4. Structures from Electrons and Protons.
5. Disrupture Processes.
6. Properties and Chemical Change.
7. The Orbital Model of the Atom.

NOTE: Address by the author at the NSTA Annual Winter Meeting in conjunction with the 127th meeting of the American Association for the Advancement of Science, New York City, December 28, 1960.

[1] Laurence E. Strong and M. Kent Wilson. "Chemical Bonds: A Central Theme for High School Chemistry." *Journal of Chemical Education*, 35:56. January 1958. (See also news bulletins available from project office.)

[2] Glenn T. Seaborg. "New Currents in Chemical Education." *Chemical and Engineering News*, 38:97. October 17, 1960. (See also news bulletins available from project office.)

8. Energy and Chemical Charges.
9. Metals.
10. Ionic Bonds.
11. Periodic Table.
12. Polar Covalent Bonds.
13. Chemical Equilibrium.
14. Acids and Bases.
15. Water.
16. Chemistry of the OH Group: Alcohols.
17. Covalent Halides and Oxyhalides.*
18. Chemistry of the OH Group: Acids.*
19. The Nitrogen System of Compounds.*

Contents of the Laboratory Manual

EXPERIMENTS

1. Observation.
2. Introduction to the Nature of Chemical Reactions.
3. Some Quantitative Aspects of Chemical Reactions.
4. The Reaction of Methane with Oxygen.
5. A Comparison of Sodium Chloride with Naphthalene.
6. An Aqueous Solution of Sodium Chloride.
7. A Comparison of Carbon Dioxide with Oxygen.
8. The Geometry of Electron Pairs.
9. Diffusion-Effusion.
10. Heat of Vaporization.
11. Heat of Formation of Solid Ammonium Chloride.

(Other experiments now in process of development.)

The following outline is a sampling of what can be done with this approach:

Sample Outline of Atomic Structure, Chemical Bonds and Properties.

1. Types of Bonds.
- a. Ionic
- b. Covalent
- c. Coordinate covalent
- d. Polar covalent
- e. Hydrogen bond
- f. Metallic

2. Structure of Atoms.
- a. Energy levels and electron clouds
- b. Spinning electrons
- c. Orbitals

3. Why Atoms React.
- a. To complete main shells
- b. To fill orbitals

4. Types of Atomic Structures that Produce Ionic Bonds.
- a. Nearly filled and almost empty orbits
- b. Atomic with much different electron attracting power

5. Types of Atomic Structures that Produce Covalent Bonds.
- a. Atoms with similar electron attracting power

6. Coordinate Covalent Bonds.
- a. One atom or group supplies both electrons
- b. Leads to modern theory of acids and bases
- c. Leads to understanding of complex ion formation

7. Polar Covalent Bond.
- a. Due to unsymmetrical electrical field
- b. Explains some properties of H_2O, such as high boiling point and freezing point, good solvent for ions, change in density of ice and water, etc.

Another innovation in this approach is the general use of the concept of energy changes, indeed *free energy changes,* in discussing the question of why reactions occur.

This group is now completing a revised edition of the text material and the laboratory problems. The course is being taught on an experimental basis in a number of high schools with reported excellent success. A number of National Science Foundation institutes are to be held during the summer of 1961 to prepare teachers to use this material in their schools.

It is certainly a laudable experiment and whether accepted *in toto* or in part is bound to have a valuable influence on improving the quality of the first course in chemistry.

The Chemical Education Material Study Approach

The general content of the syllabus of this study originated from a study made by a committee appointed by a conference group of chemistry teachers brought together by the American Chemical Society and the National Science Foundation in 1958.[3] In order to avoid needless duplication of the content items in the high school and college courses, the committee recommended a project be explored of *identifying the irreducible minimum of basic fundamentals that could and should be taught in the high school course and on which the college course would then be built.* It was proposed that the syllabus for the high school course should be built around these fundamentals; it was also proposed that this study should include the other ancillary features of the course, namely, laboratory problems, demonstration problems, addendum reading materials, visual aids, teachers guides, etc.

At this date the first edition of the text and the laboratory manual are available. The two tables of contents follow:

Table of Contents of Text for First Course

1. Chemistry: An Experimental Science.
2. Introduction to Atomic Theory.
3. Atoms Combined in Substances.
4. Chemical Reactions and Phase Changes.
5. The Gas Phase: Kinetic Theory.
6. Substances and Solutions.
7. Chemistry and the Periodic Table.
8. Geochemistry: The Earth as a Source of Material.
9. A General View of Chemical Reactions.
10. Energy Effects in Chemical Reactions.
11. The Rates of Chemical Reactions.
12. Equilibrium in Chemical Reactions.
13. Ionic Solutions and Reactions.
14. Acids and Bases.
15. Oxidation-Reduction.
16. Chemical Calculations.
17. Believing in Atoms.
18. Periodicity of Chemical Properties and Electronic Structure.
19. Molecules and Their Structures.
20. Structure in Solids and Liquids.
21. The Chemistry of Carbon.
22. The Halogens.
23. The Third Row of the Periodic Table.
24. The Second Column of the Periodic Table.
25. The Transition Elements.
26. Biochemistry—the Chemistry of Living Matter.

Table of Contents for Laboratory

Introduction: Observation and Description.

EXPERIMENTS

1. Melting Points.
2. Chemical Reactions of a Burning Candle.
3. Heat Effects.

* Tentative only.

[3] This committee was composed of Robert Silber, High School Teacher, Evansville, Indiana (now with Educational Section, American Chemical Society); Farrington Daniels, University of Wisconsin, Madison; Bryce Crawford, University of Minnesota, Minneapolis; Herbert Carter, University of Illinois, Urbana; Arthur Roe, University of North Carolina, Chapel Hill; Leonard Nash, Harvard University, Cambridge, Massachusetts; and A. B. Garrett, The Ohio State University, Columbus (Chairman).

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This, too, is a laudable experiment and promises to have a far-felt influence on the instruction of the first course in chemistry.

Trends in the New Chemistry

The results of earlier renovations added to the progress to date in these two major studies make it possible to point out several specific changes that are now already widely accepted in teaching the first course in chemistry. Examples of several of these of both major and minor nature are summarized here:

A. Changes in Theory.

1. The objective of chemistry can now be stated as a method of interpreting the phyical universe.
2. Chemistry should be presented as an evolving, dynamic method of exploring the universe that has many new problems yet to be solved.
3. In the area of structure:
   a. The importance of the octet (or rule of eight) should be minimized and emphasis should be given to orbitals or pairs of electrons (rule of two). If the atomic orbital theory is used, teach it as *a* method of explaining chemical bonding—not as *the* only method.
   b. Teach the concept of polar covalent bonds and hydrogen bonding.
   c. Introduce the concept of subshells and use the concept of unfilled subshells to explain the properties of the transition elements.
   d. Use data on ionization potentials to teach the relative electron attracting power (or electronegativity) of atoms and hence predict whether they will form ionic or covalent bonds.
   e. Relate structure of compounds to their properties.
4. In the realm of definitions or new terms:
   a. The term *oxidation number* is used as a means of bookkeeping for oxidation-reduction changes.
   b. The term *mole* has general usage as an abbreviation for a gram molecular weight, a gram formula weight, or an Avogadro number of particles.
   c. The *anode* is now defined as the electrode at which oxidation occurs.
   d. Be on the alert for many new terms that are filtering down rapidly into the first course. Examples of these are: barn, resonance, Lewis acid, hybrid, cross section for neutron capture, neutron activation, etc.
5. Use the concept of activation energy and distribution of energy of molecules to explain chemical processes.
6. Use graphic relationships as a means of developing visualization and stimulating imagination.
7. Introduce chemical equilibrium and the driving force of chemical reactions.
8. Extend the concept of "simplification by classification" for the elements in the periodic table grouped in 18 families and for the organic compounds grouped in the 9 common families; this is an extrapolation of the concept that "elements whose atoms have similar electron configuration have similar properties" to "groups of atoms that have similar electron configuration have similar properties."
9. Show that some of the world's great literature is now in science.
10. Minimize industrial processes.
11. Point out problems yet to be solved.
12. Discuss topics not included in the text.
13. Weave in the historical items as they are of value in illustrating the method of science, or the evolving character of science, or as they may serve or interest stimulators.

B. Changes in Methods of Teaching.

1. Use the text as a reference text; use several graded texts.
2. Develop better demonstration problems and laboratory problems with emphasis on the "problem" feature and interpolation of experimental data.
3. Consider the use of tasks or research projects or method of problem solution.
4. Develop a better type of quiz and examination question.

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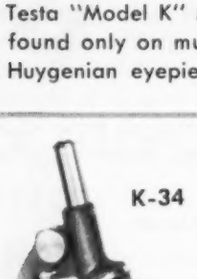

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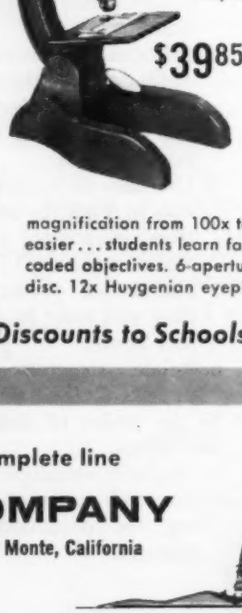

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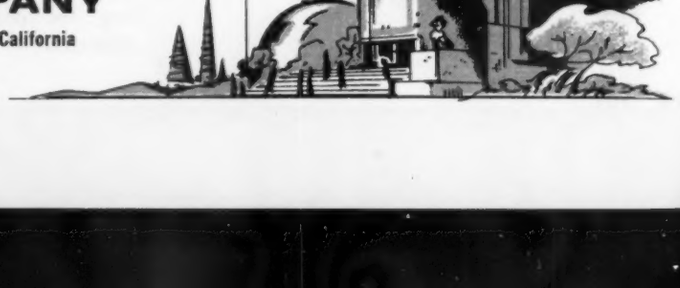

5. Search for effective use of models and visual aids.

Evaluation of Reports of Studies

A mere listing of the table of contents of the textual material does not do justice to either of these studies. The texts must be read carefully to get a full appreciation of the value of each proposed program. The directors of these studies welcome a rigorous, critical evaluation of their reports. But in all fairness to the staffs and to the cause for which we are all working, the writer urges that such criticism be constructive and that those who criticize should be prepared to give an alternative that too could stand for rigorous evaluation. As the merits of these studies are being evaluated, it must be recognized that this planning is not an expedient—it is long term; but even these long-term plans will require alteration as time and events bring additional need for change. It is not expected that immediate nationwide adoption will be realized in either of these syllabi. Some teachers may feel prepared to accept one or the other immediately, and most teachers will adopt parts of the program over a period of time. Both programs have their merits. Remember that directors and teachers alike are searching for the answer to the question "How can the most dramatic subject matter of the whole academic curriculum best be taught and caught?" We must all help to find the answer.

The Preparation of the Teacher

In 1959 and again in 1960 the Cooperative Committee of the American Association for the Advancement of Science published its recommendations for the preparation of science teachers.[4] These reports have been the subject of discussion on a national basis at the annual meeting of the Teacher Education and Professional Standards group of the National Education Association at Bowling Green, Ohio in 1958, Lawrence, Kansas in 1959, and San Diego, California in 1960. Teachers with this type of preparation from the modern college classroom should have no difficulty with this "New Chemistry." Teachers with less than this preparation may have to upgrade their preparation. The many institutes, both the Summer and Academic Year Institutes, are serving very effectively to remedy this problem. Much more needs to be done.

Conclusion

We recognize that the rapid changes in science and technology have forced us to consider seriously the question of what should be included in a first course in chemistry. Today there is a nationwide interest on both an individual and collective basis to find the answer to this question. The two national studies will give impetus to the acceptance of new ideas to be included and new methods to be used. Teachers individually and collectively will also make their contributions. Good teaching requires that we all contribute to this ever-growing edge of new ideas and better methods of teaching one of the most dramatic disciplines of the modern day. We must accept with enthusiasm the admonition of the poet—

> New occasions teach new duties
> Time makes ancient good uncouth,
> He must upward still and onward,
> Who would keep abreast of truth.

[4] A. B. Garrett. "Recommendations for the Training of Science Teachers." *School, Science, Science and Mathematics*, 59:281. April 1959. "Preparation of Science Teachers." *Science*, 132:1024. April 8, 1960.

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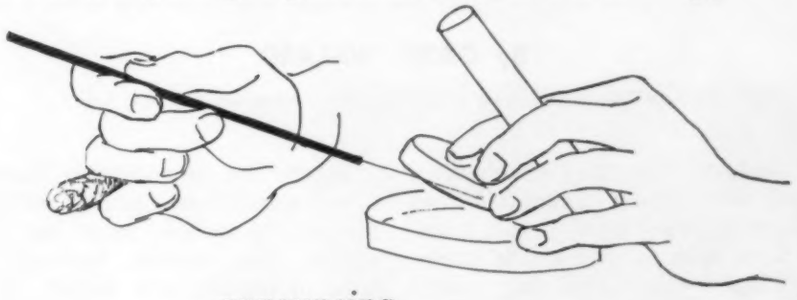

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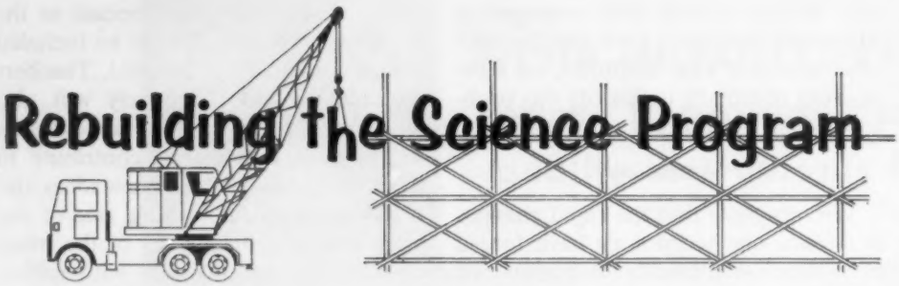

Earth Science

The Importance of Earth Sciences in the Curriculum

By GATES WILLARD

Science Teacher, Manhasset Junior High School, Manhasset, L.I., New York

IT might be interesting to conduct a poll which would request a vote on the relative importance of two scientific fields such as geology and chemistry. The results would vary widely according to who was replying. Understandably, the views of chemists and geologists could be expected to be somewhat prejudiced! On the other hand, a geochemist might have a mental breakdown while trying to weigh separately two sciences which he imagines to be mutually supporting. After all, virtually every "chemical" studied by man comes from the crust of the earth. The science teacher might cast his vote according to the kinds of experiences he has had. If, for example, his college geology course was uninspiring, he may favor chemistry. Yet he surely is aware that the earth is important to him. Literally, where would he be without it? Eventually, the high degree of inconsistency in the replies would probably cause the poll to be abandoned.

Which is the more important part of an automobile engine—the carburetor or the fuel pump? The question is absurd; the absence or failure of any of a number of components would prevent the engine from running. The scientific enterprise includes many interrelated and interdependent areas. Is it any more logical to vote upon whether some fields of science are more important than others?

In this era of constantly changing school curriculum there is mounting pressure to include more and more science. The schools, however, can hope to include only morsels of the vast fields of science which are expanding far more rapidly than curriculum. Is there really justification for adding geology, astronomy, meteorology, and related sciences to an already overcrowded school program? Are any of these areas *important* enough to *replace* something that is presently included?

The Curriculum Problem

How is school science subject matter chosen? Decisions are frequently made about what should and what should not be part of the program. Most persons involved in science curriculum planning are specialists in biology, chemistry, physics, or combinations of these. If there were no room in their professional training for courses in geology, astronomy, or meteorology, would these people attach importance to the teaching of earth science areas?

In many schools, the earth sciences have been treated to some extent as a minor portion of general science. However, there are a number of more sophisticated principles and concepts which might better be developed at a higher level. Why are high school students deprived of experience with these? The traditional high school science courses continue to be biology, chemistry, and physics. Usually there is a syllabus which effectively keeps the teacher on a straight but narrow path. Teachers often claim that there is more than enough material in their own subject areas. Why should they even consider introducing fields which are unfamiliar to them? Perhaps these teachers are unaware of the strong relationship of the earth sciences to biology, chemistry, and physics.

What the Earth Sciences Can Do for the School Science Program

The subject matter of any science course should not be considered apart from the methods by which it is taught. *Any* science may be presented in a descriptive, and unchallenging manner. The earth sciences can be dynamic and vitally interesting, and problem-solving techniques may be used at least as readily as in other science courses. Moreover, some unimaginative teachers have presented earth science as a glorified story about the landscape with a little practice in rock identification from a key. Perhaps some constellations were memorized, and students learned how to read a weather map. Many a teacher has been unable to transfer depth of understanding to his students because his own formal training in the earth sciences has been lacking or incomplete. This is not an uncommon malady among chemistry, physics, biology, and general science teachers, but because earth science is a relative newcomer to the schools, the problem is particularly acute.

Since there appears to be a lack of awareness of the potentialities in earth science teaching, the balance of this article is devoted to a discussion of what the earth sciences can do for the school science program. A few specific examples are listed below:

1. The earth sciences are environmental in scope. The student can develop greater understandings and appreciations of his natural surroundings. Local field trips can yield important information about the geologic history of an area and man's use and misuse of his natural resources. Brief trips to the schoolyard itself can reveal weathering and erosion at work. Students can see that natural forces are changing the earth today as in the past.

2. Interest in the principles of light and optics can be aroused when they lead into a study of the heavens by

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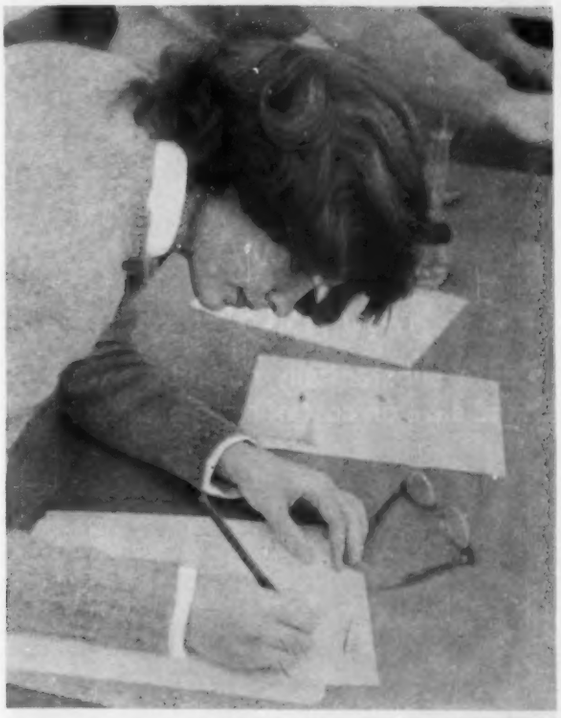
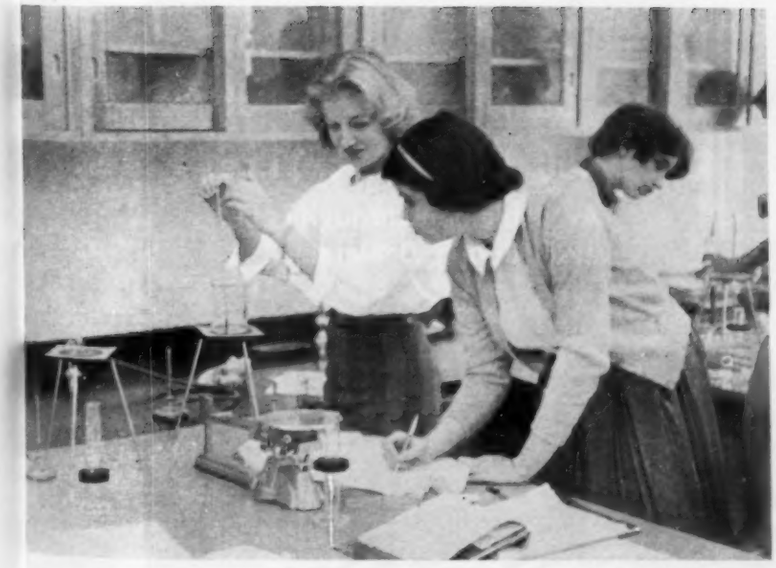


After the experiment, the recording of observations and preparation of a report absorbs the interest of the ninth graders.



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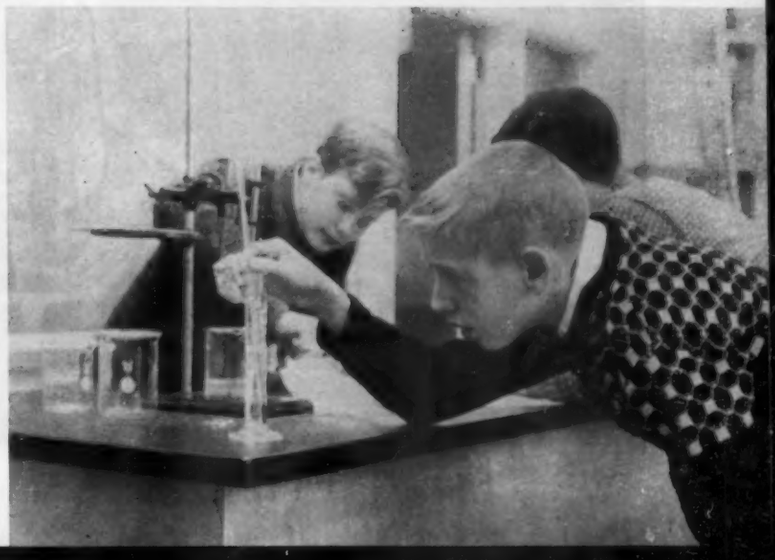

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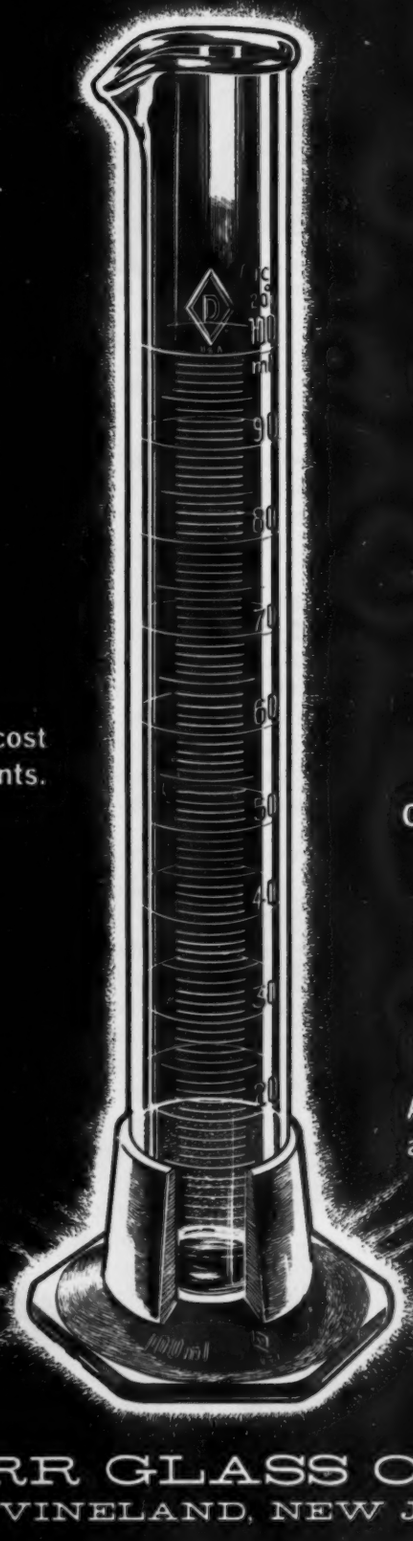

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means of a telescope. Students are intrigued to discover how radiant energy from outside the earth is practically the only source of information about the universe.

3. Depending upon the location of the school, certain ecological projects may be undertaken. For example, the relationship of ancient as well as modern marine life to the physical environment may be studied in fossils or marine forms found on the beach.

4. In an introduction to minerals and rocks, many important chemical concepts can be emphasized. Students learn the value of determining physical and chemical properties with accuracy in identifying minerals. By studying and growing crystals similar to those found in rocks, students can learn far more about the behavior of atoms, molecules, and ions than a mere discussion could impart.

5. Earth science is of strong current interest. The impact of the International Geophysical Year is only beginning to be felt, and it is not necessary to elaborate here upon the need for space education. Strontium 90 in the atmosphere, the oceans as mineral resources, conservation of natural substances, and searching for new materials are topics of vital concern.

6. There are numerous opportunities for club and hobby activities. Students can build their own weather instruments to record data on atmospheric changes. Those who are ambitious may want to construct telescopes, grinding and polishing their own mirrors. Mineral, rock, and fossil collecting are hobbies that can be maintained throughout life, and an inexpensive lapidary unit provides a source of pleasure for those who want to polish stones and make their own jewelry. This activity is enjoyed equally by boys and girls.

7. Earth science draws heavily upon biology, chemistry, and physics. An excellent medium is provided for demonstrating the *interdependence* of science fields. There is hardly a principle of physics that cannot be applied to the dynamic earth and other bodies of the universe. Virtually every substance used by man comes from the earth. The theory of evolution is based upon fossil evidence. It is interesting to note that most geology majors are required in college to take at least one year each of chemistry, biology, and physics in addition to their geological training.

8. There are excellent opportunities for integration with other courses. The tie to geography is obvious. Natural resources, the effects of climate upon the world's inhabitants, the dangers of atomic radiation, and the impact of new earth science discoveries upon society are topics which are treated in social studies as well as in science classes. Various types of models and visual-aid material may be constructed in art and shop classes.

9. With increasing emphasis upon laboratory experiences, the earth sciences have a great deal to offer. In addition to the outdoor laboratory, much can be accomplished in the classroom. A few subjects which may be investigated are listed below:

1. Reflection and refraction of light.
2. Determination of chemical and physical properties in minerals.
3. Identification of minerals by means of specific gravity.
4. Properties of water.
5. Principles of crystal growth.
6. Nature of solutions.
7. Evidence of evolution in fossils.
8. Gravity.
9. Map making.
10. Bernoulli's principle.

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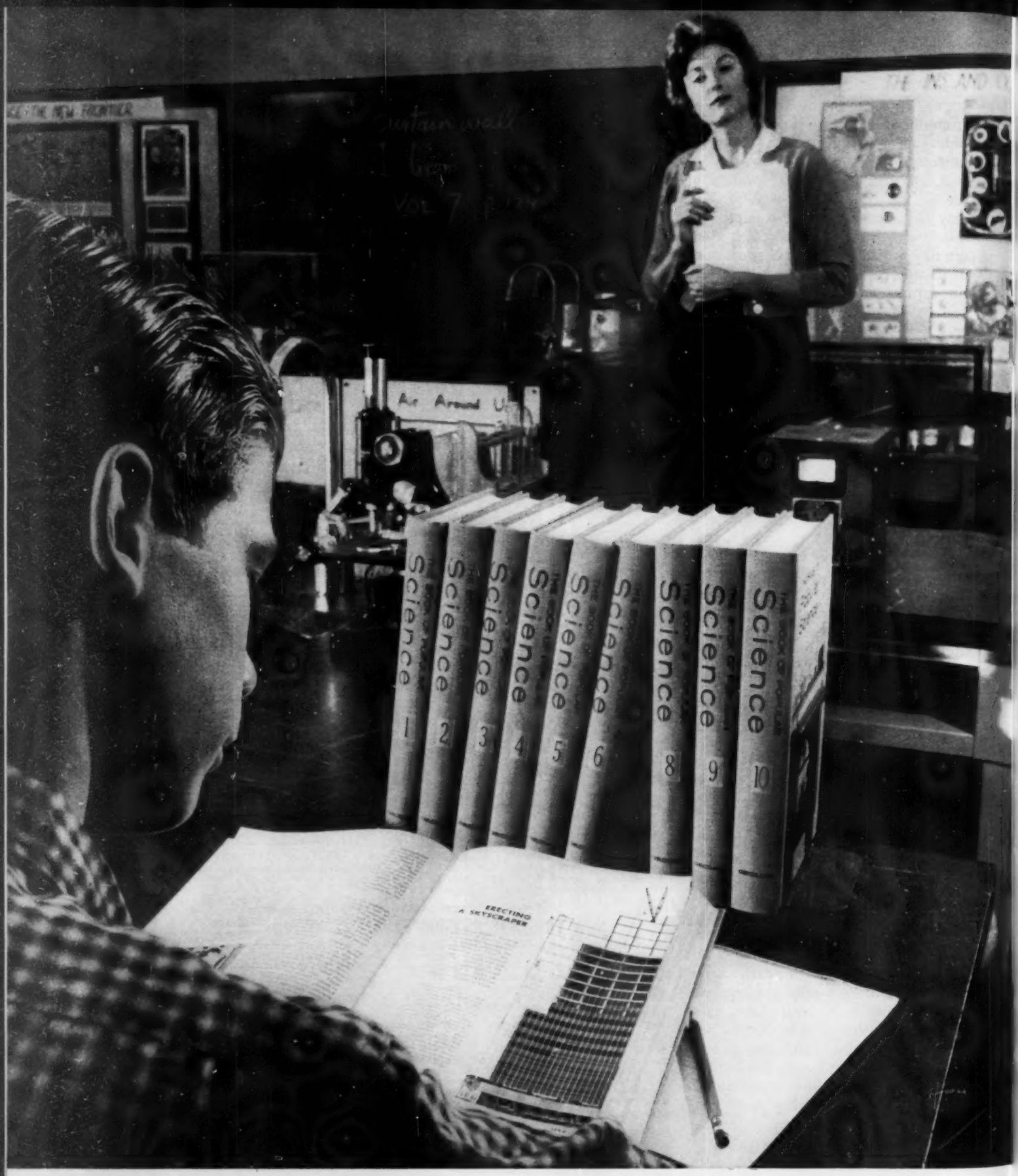

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Finding a Place for Earth Science

If an earth science course could be a worthwhile part of the curriculum, what would be replaced? If earth science is put in, something will have to go. General science seems ripe for change. There are several reasons for disillusionment with it—particularly at the ninth-grade level.

1. Students become bored with "general" science year after year. This is particularly apparent in schools having a successful elementary science program. In the ninth grade, specialization in mathematics and language is common. Aren't students ready for a less "general" science course?

2. General science is usually a hodgepodge of unrelated information taken from too many areas to permit study of anything in depth. Today students are learning about insects, and next week they will study atomic energy. How will they ever discover the interrelationships of scientific disciplines? What is general science? It defies definition! What guides are used to decide the areas that should be included?

3. There is a decided tendency for repetition of subject matter from year to year since general science usually skims lightly along the surface, barely touching upon a multitude of units and never treating any of them in detail.

4. Where can teachers be found who have a broad knowledge of many growing science fields? Some general science teachers are trained only in biology, chemistry, or physics. Many general science teachers are not well trained in any science field. What *is* the best training for a "general" science teacher?

5. How is it possible to plan what is to be taught at the various grade levels considering the diverse training, experiences, and abilities of teachers? What happens to the program when teachers leave the school system?

In some states such as Pennsylvania and New York, ninth-grade earth science is replacing general science in an attempt to solve problems such as those listed above. In the new course, it is possible to relate the earth to its atmosphere and the universe. With this unifying thread it offers a distinct advantage over the usually conglomerate "general" science. A small number of science areas are explored in depth so that students have a better opportunity of finding out what science is really about. Repetition and duplication are avoided. The course is unlike what is being taught at higher as well as lower levels. With depth of study, laboratory experiences are particularly important. Students can develop skills in handling basic equipment needed also in biology, chemistry, and physics. The course provides excellent training for students who will take other science courses. Teacher education is simplified. The ninth-grade earth science teacher has definite goals for which to train. He can become a specialist in a few areas rather than knowing too little about too many subjects.

The Status of Earth Science

Pennsylvania and New York have large-scale, rapidly growing earth science programs, although much of the teaching is being done by under-trained but enthusiastic personnel. In New York where the course has been offered for many years, earth science is being recommended for gifted ninth graders, but much of the course can readily be adapted to the needs of most students. Some New York high schools offer earth science as an alternative to biology, chemistry, or physics, thus creating a fourth science elective. Several other states have initiated or are contemplating earth science programs.

In anticipation of the growth in earth science teaching, the National Science Foundation is supporting the American Geological Institute in the development of earth science teaching resources. During the summer of 1959, twenty geoscientists and ten teachers assembled at the University of Minnesota in Duluth for the purpose of considering concepts of course content and cataloguing, evaluating, and developing teaching materials. Since the Duluth conference, preliminary copies of the sourcebook have been undergoing testing by 100 teachers in selected areas throughout the United States. At present the materials are being revised and edited in preparation for publication in 1961.

Three earth science textbooks are on the market. A fourth will enter the field early in 1961, and at least one more publisher is planning a text.

Someday, earth science may well achieve a status in the schools equivalent to that of biology, chemistry, and physics. As a new kind of course, it does not have to fit a traditional pattern. Any school that is searching for a *different* kind of science course would do well to investigate the advantages of instituting earth science.

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Science Education

A Proposed Three Track System

By JOHN P. HARROLD

Head, Biology Department, Senior High School, Midland, Michigan

WHILE this proposal chiefly concerns the high school, the ultimate success depends upon an integrated science program reaching down and into the kindergarten level. In addition, an informed and impartial guidance program is essential. The purpose of this program (Track III) is an early identification of the talented student, especially his potentials in the fields of science and mathematics. It must be recognized also that important obligations are due those students who are not considered in the talented group.

The latter students are numerically greater, and they represent the larger "mass." It is well known that the greater the mass the greater the resistance to movement, but once the mass is in motion it is equally difficult to stop. Thus, it is feasible to start the motion in the right direction. All students, each according to his capacity, should receive education in the fields of science and mathematics. The future advancement of civilization depends upon this. Furthermore, something must be done about the situation, not tomorrow or next year, but today.

Three types of science students may be recognized: (1) the student who in all probability will not extend his formal education beyond the twelfth grade, (2) the college preparatory student with average to high ability who is chiefly interested in fields other than science and mathematics, and (3) the talented student possessing unusually high interests, abilities, and potentialities. Each of the three, while receiving training commensurable to his abilities and interests, must be made aware of and understand the impact that science is now having and will continue to have on our society. This impact not only presents a challenge to the science teacher, but also imposes an obligation on the social studies teacher.

It has been observed that less resistance to ability grouping exists than in previous years. Society has always grouped itself, deliberately or unconsciously, according to common interests and abilities. It is my preference to think of students in groups whose members share common interests and subject-matter preferences.

The success of the Track III program for talented students will depend upon early identification of such a student as reflected in elementary school progress reports and the testing and counseling program of the junior high school. Furthermore, a good laboratory course in systematic biology should be offered at the ninth-grade level. High IQ, previous academic achievement, and an interest in science should be the criteria for the selection of biology students at this level. In addition, parents should understand and cooperate in the objectives of Track III.

These objectives might well be: (1) to develop the full potentialities within the student by stimulating curiosity, challenging his intellect, and developing appreciation for the contributions of many great scientists toward the concepts of the present day; (2) to allow the student to explore his field of interest through directed experimentation; (3) to offer the opportunity for individual development of ideas through research-type projects; and (4) to develop a background that may lead to advanced placement or, in some cases, to advanced standing when the student enters college.

To reiterate, the student considered here has unusual abilities, potentialities, and enthusiasm. He deserves to be encouraged in every way to develop these qualities. Certainly, assignments requiring additional reading and reporting are a poor substitute for "doing." In the application of the study, the need for and value of additional reading will become apparent. The student who works hard of his own accord is interested in what he is doing and the work ceases to be hard.

Two questions usually occur in the discussion of the Track III program with parents and students. They argue that (1) if the student finds the work in the talented section too difficult because of the high standard, would it be

TABLE I

A Three Track System for Senior High School Science

BASIS FOR SELECTION	GRADES OFFERED			
	9	10	11	12
TRACK I IQ Average or Below RC Below 50 Percentile VI Below 50 Percentile Grades Below Average Interest Below Average	General Science	Biology 100	Physical Science 100	Physical Science 100
TRACK II IQ Average or Above RC Above 50 Percentile VI Above 50 Percentile Grades Average or Above Interest Average	Physical Science 200	Biology 200 Chemistry 200	Chemistry 200 Biology 200 Physics 200	Physics 200
TRACK III IQ Over 125 RC Above 80 Percentile VI Above 80 Percentile Grades High Interest Very High	Biology 300	Biology 300 Chemistry 300	Chemistry 300 Biology 400 Physics 300	Chemistry 400 Biology 400 Physics 400 Seminar 400

IQ—Intelligence Quotient
RC—Reading Comprehension
VI—Verbal Interpretation

↕ — Parallel classes to which a student may change if desirable.

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easier for him to achieve a high grade in the regular class; (2) therefore, why not allow him to remain in the regular class? The first question is legitimate and well chosen. If the best interests of the student are served by his transfer from a talented to an average class without loss of credit, then this should be made possible. The transfer will, of course, necessitate scheduling parallel classes to minimize reshuffling of students. If good selective criteria are used, however, this situation should seldom occur. The student also often welcomes change that benefits his total program.

The second question, when it arises, is more difficult to answer. Numerous ways of meeting the problem of retaining the talented student in a regular class have been attempted. One suggestion is to assign different numerical values to the letter grades. In most high schools, senior scholastic averages are figured on numerical values. Thus, the letter grades *A*, *B*, and *C* of the talented class might be assigned values 5, 4, and 3, while the assigned values in the regular class might be 4, 3, and 2.

Rather than designate courses as Grades 9, 10, 11, or 12, it is suggested that numbers be used to indicate the level of difficulty. For example, a course in the more elementary principles could be assigned the number 100; a similar course of a more intensive nature geared to the college preparatory student might be numbered 200; and a comprehensive course with opportunities for individual investigations might be numbered 300. Any second-year course in the same subject area might be assigned the number 400. On this basis, it is assumed that courses for the talented student would be labeled 300 and 400. (See Table I.)

The development of course content for three ability levels, in itself, presents a real challenge. Serious and careful consideration should be given to the selection of the areas to be covered and the extent to which they should be explored. This decision should not be made by any one teacher, but arrived at by pooling the recommendations of those teaching prerequisite courses. No course will be developed that will be a remedy for all ability levels of students. On this point we should be thankful for our democratic system of education that permits different objectives and obligations for each school system. Regardless of the individuality of the community, the three types of students we are considering will always exist.

Although the task of determining a course content suitable for all ability levels may seem insurmountable, it should be remembered that outside resources are available. National, state, and local organizations are investigating all aspects of course content and objectives, methods of presentation, and student abilities. Among those which can offer recommendations and furnish publications are the National Science Teachers Association and its various committees, the National Association of Biology Teachers affiliated with the American Institute of Biological Sciences, the National Association for Research in Science Teaching, the United States Department of Health, Education, and Welfare, national and state education associations, and state boards of education. In the final analysis, however, decisions made at the local level in the individual school system will produce the actions needed to arrange the grouping of students according to ability levels.

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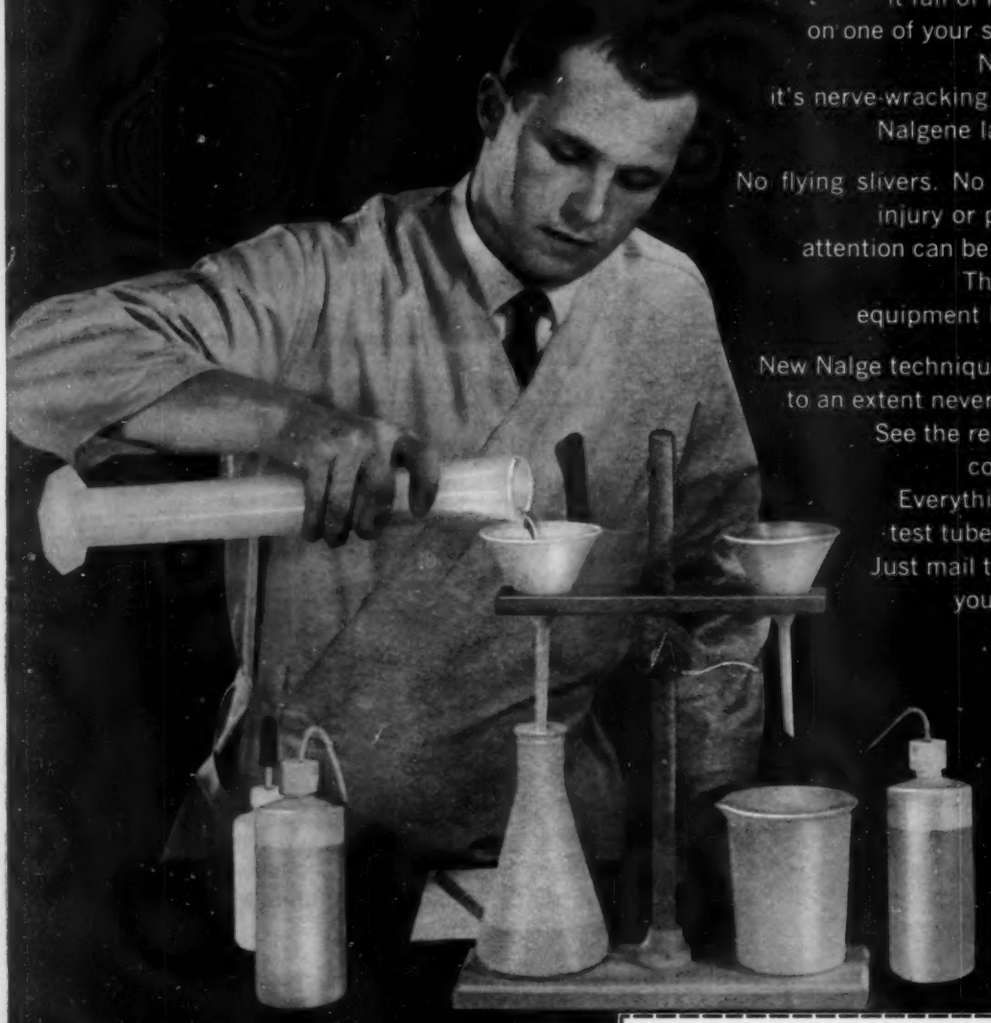

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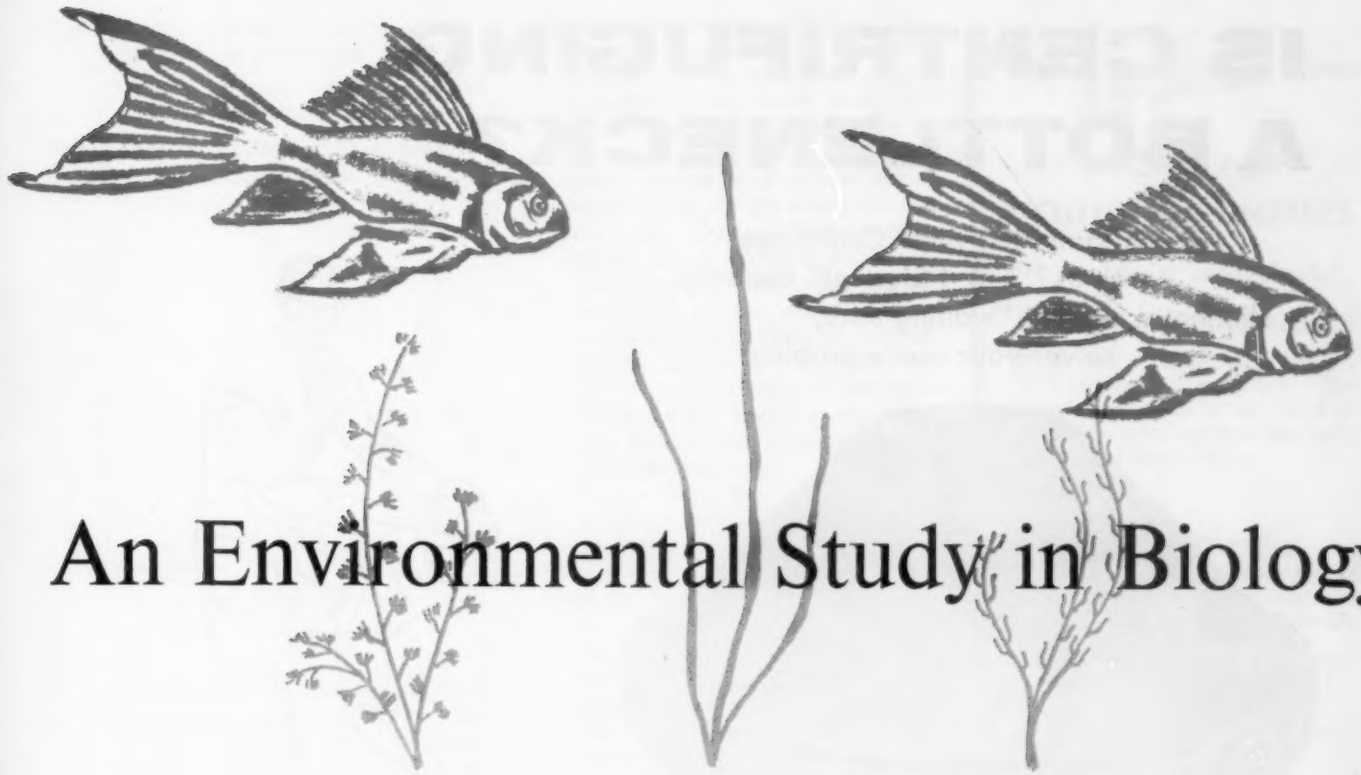

An Environmental Study in Biology

By THOMAS M. HAYNES

Biology Teacher, George Washington High School, Indianapolis, Indiana

This report was an entry in the STAR (Science Teacher Achievement Recognition) awards program of 1960, conducted by NSTA and sponsored by the National Cancer Institute, U. S. Public Health Service.

As a part of the technique of problem solving in individual and group laboratory work, the study of living organisms should be utilized not only as a necessary component of a problem, but also as an opportunity of developing in the student acute habits of observation and proper methods of handling and caring for an organism.

Of the vertebrates, fish are easy to handle and make excellent subjects for anatomical and physiological studies. The Comet goldfish, because of its availability and rugged adaptability, has become a favorite in many school laboratories.

Equipment includes aquarium, crushed ice, thermometer, and timer.

Preliminary studies of the fish should include a thorough study of external anatomy with emphasis on structures which enable it to adapt easily to its water environment. One method of observing the anatomical structures of a fish is to place a single Comet in a small aquarium or gallon jar and watch it swim about for a few minutes. The function of the various fins in locomotion and balance soon become apparent. Other characteristics such as the size of the eye, the relative size of the pupil of the eye, the position of the eye on the head, the streamlined body, the arrangement of scales, and the sequence of mouth and operculum movement should be observed in this preliminary study by the student.

Since the fish is a cold-blooded organism, temperature fluctuations in its water environment result in marked internal and external metabolic activities. Demonstrating the effect of seasonal changes is one of the most interesting experiments that can be performed by any high school biology student. A minimum amount of equipment is needed: a small aquarium, a thermometer that can be immersed in water, crushed ice, a timing device, and a supply of Comet goldfish.

Procedure:

1. Place the fish in an aquarium so that the dorsal fin is just covered by water.
2. Place a thermometer in one corner

Student prepares data sheet for experiment.

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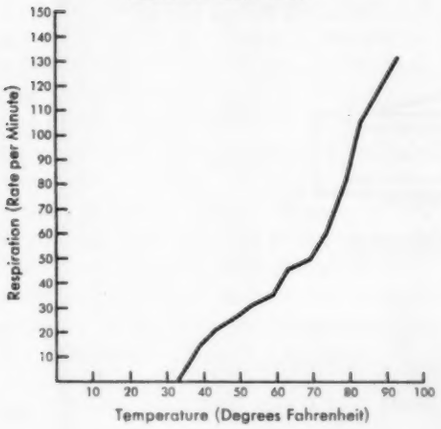
of the aquarium so that it may be read without disturbance.

GRAPH I

The Influence of Water Temperature on the Average Respiration Rate of Six Fish



3. After preliminary observations have been made, *slowly* add crushed ice to the aquarium until the temperature of the water is reduced to near-freezing. Caution should be exercised in adding the ice. Add it slowly so that the temperature change is gradual and the factor of shock is reduced to a minimum. The ice should be handled carefully also so that the fish is not unduly excited.
4. At the near-freezing temperature, observe the movement of the operculum which covers the gills. Water enters the mouth of the fish; the mouth is closed; the operculum opens, and water is forced out over the gill filaments. As the water passes over the filaments, oxygen dissolved in the water enters the thin-walled capillaries that are so abundant in the gill filaments, and excess quantities of carbon dioxide are released from the capillaries into the water. The open operculum indicates that a complete respiratory cycle has been completed, and the movement of the operculum becomes a good method for computing the respiration rate of the fish.
5. Count the movement of the operculum for one minute at near-freezing. Record the temperature and the respiration rate.
6. Slowly add hot water to the aquarium until a five-degree rise in temperature occurs. The water should be poured into the aquarium at the end opposite the thermometer. Again, use caution in adding the water to keep the fish from becoming excited. Remove an equal quantity of water from the aquarium so that the water volume remains constant. Record the respiration rate at this temperature for one minute.
7. Continue to add hot water and record the respiration rate for each five-degree rise in temperature until the temperature approaches 90°F.
8. Remove the fish and place it in a well-aerated tank which is at room temperature.

An analysis of the effect of temperature on the respiration rate of fish should include the contributions and observations of the entire class. From

TABLE I

Relationship between Water Temperature and Respiration Rate in the Comet Goldfish

Degrees Fahrenheit	*Fish No. 1*	*Fish No. 2*	*Fish No. 3*	*Fish No. 4*	*Fish No. 5*	*Fish No. 6*	*Average Rate*
32	0	0	0	0	0	0	0
37	12	10	14	13	20	11	14
42	19	16	17	25	23	20	20
47	23	26	23	28	25	22	25
52	27	31	30	33	30	28	30
57	31	35	35	40	35	32	35
62	45	46	42	46	40	40	44
67	53	48	45	53	47	45	49
72	57	58	60	67	54	50	57
77	90	88	70	77	86	75	81
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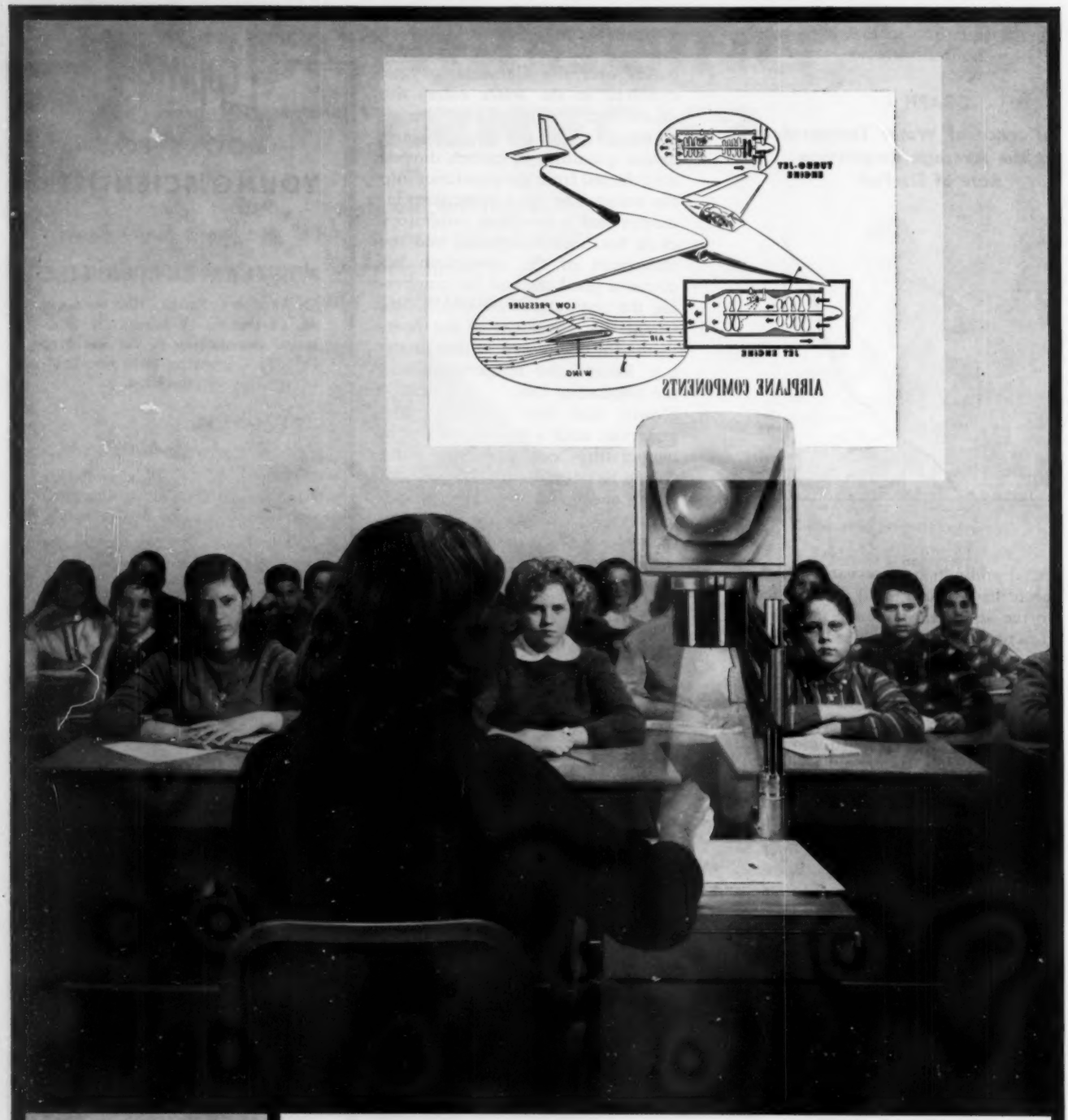

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the data collected by individual class members, an average respiration rate for each five-degree interval of temperature may be computed. Each student can then construct a curve (see Graph I) and record the data (Table I).

The student should then analyze all of the data that has been collected and correlate it with the observed metabolic activities of the fish. He should observe that the fish is immobile at near-freezing temperatures with no perceptible movement of the operculum. This corresponds to a state of suspended animation when the animal is near death. He should also note the temperature at which the greatest metabolic fluctuations occurred and the fact that as temperature increased, the respiration of the fish simultaneously increased.

In addition to temperature, students can list other variables that might affect the respiration rate of the fish. Certainly, the metabolic activities of the fish would be influenced by such biological factors as health, age, size, muscular activity, and emotional stress and such physical factors as the oxygen and the mineral content of the water.

The results of this laboratory experiment can stimulate further reading and research. Additional research by the student will reveal that the normal respiration varies among the fish from "12 per minute in the wrasses, to as high as 150 per minute in the minnows." [1] Other areas of exploration could include the effect of temperature extremes on the enzymes of respiration and the effect of oxygen starvation (anoxia) on the internal tissues of the fish or other parts.

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4. Alfred Morgan. *An Aquarium Book for Boys and Girls*. Charles Scribner's and Sons, New York. 1951. p. 14-33.
5. J. R. Norman. *A History of Fishes*. Ernest Benn Limited, London, England, 1951. p. 33-54.

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By ARTHUR C. MURDOCK

Science Instructor, Sutton High School, Sutton, Massachusetts

AS science teachers, are we able to say that we have been open-minded about some of the recent technological advances that have been put forth to aid learning? Have we been willing to try some of these new ideas in our own teaching situations, or are we still staunchly clinging to our old lecture-recitation approach and defending it by pointing out that it can't be too bad because some of our students have gone on to college and done well?

Many of us take the view that subject matter alone is important and tend to scorn or overlook the learning process and teaching techniques. There is no argument against a knowledge of subject matter—naturally the more the better—but this does not mean that we have a right to overlook the art of teaching itself. Teaching is a form of communication, and all the subject matter in the world will not in itself aid us in transferring our treasure of knowledge to others. As teachers, we cannot afford to ignore methods of communication. Although we may present scientific subject matter, we are primarily teachers not scientists. It is our job to teach science as well as an appreciation for it, and I believe that we are missing the boat when we fail to utilize some of the modern techniques which could enhance our instruction and possibly make it more effective.

Perhaps the dilemma arises from the numerous subject-centered courses that we must have to effectively teach subject areas. Secondly, in preparing to teach we have had less opportunity to examine carefully the art of teaching.

One of the recent innovations to aid learning which is in the experimental stage is the so-called "learning machine." It might be well for us to look critically at such devices and see if we cannot contribute to the evaluation of these machines in terms of what they might be able to do for us in the area of science instruction. I have included sketches of a simple design that I built to experiment with the possibilities in my own classes. (See Figures 1 and 2.) In the footnotes are listed references [1, 2] for many other designs, some of them available commercially.

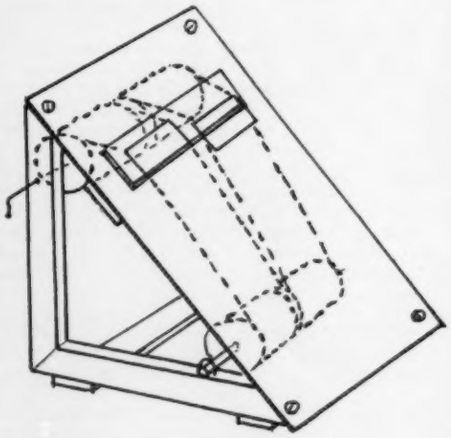

FIGURE 1.

The psychologists tell us that among other things, learning depends on such factors as repetition, continued recall, active participation in the learning process, and a feeling of achievement. The proponents of the teaching machines claim that these qualities are built in or a part of these devices. Basically, the machines consist of a method whereby the student working alone can learn in an orderly, progressive manner. Questions in logical sequence are moved into his view one at a time. The student answers the question by writing the proper response on the movable tape (it may be adding machine paper). Upon moving the tape a short distance, the correct answer appears and, at the same time, the student's answer moves under glass where it cannot be changed. The student then writes the proper response which is in his view. Each time he sees his answer and the correct one together, and he knows that he is wrong or right. The procedure remains the same until the lesson is finished. The student's answer tape may then be removed from the device, the master or programed mate-

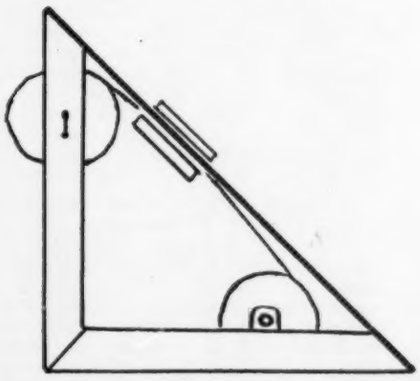

FIGURE 2.

[1] Chester D. Babcock. "The Teacher, TV, and Teaching Machines." *NEA Journal*, 49:30. May 1960.

[2] Gene C. Fusco. "Technology in the Classroom—Challenges to the School Administrator." *School Life*, 42:18. March 1960.

rial is rewound, and the process may then be repeated.

Notice how the learner is actively participating in the process and repeating the responses in a meaningful way, directed in the effort by a master tape which must be designed with careful planning by the instructor. The student cannot skip around haphazardly, but must accept the new material in a logical sequence. By comparing successive answer tapes, he can see, or even graph his rate of improvement. This also introduces to the student the feeling of satisfaction for accomplishing a given goal through his efforts.

Naturally, the device is not intended to replace teaching, but perhaps it can aid the science instructor in designing effective and meaningful drill which is overlooked entirely or left to the student to figure out for himself without aid or direction. Students should have an opportunity to work things out for themselves, but methods of study should not be included in this category.

Research in this area could be done to advantage by interested high school instructors with the participation of their students who could easily increase their effectiveness in the subject matter. Some of the projects could be centered around the following questions:

1. Compared to other methods of study, is the machine effective?
2. Is the machine more valuable to the slow, average, or rapid learner?
3. Can the machine be used for presentation of concepts as well as rote memory work?
4. What is the optimum number of questions to be used on the program tape?

Any one of the sciences might be tried to determine the value of the machines, for any one of them has basic formulas, nomenclature, concepts, etc., which might be taught in part by the programed method. The machines could prove valuable as a better utilization of students' study-hall time, supplying directed study material without the presence of the instructor.

As science teachers, we should be alert to new educational devices and methods which might aid us to be more effective teachers. We should not close our minds to educational research, but whenever possible, should contribute to this search for new and more effective means of transferring our subjects or knowledge of them to students.

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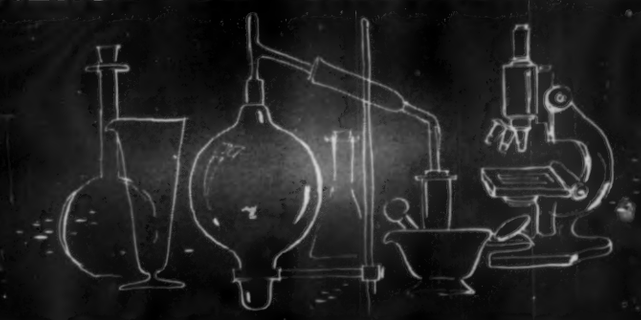

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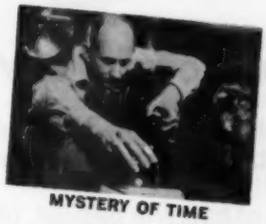

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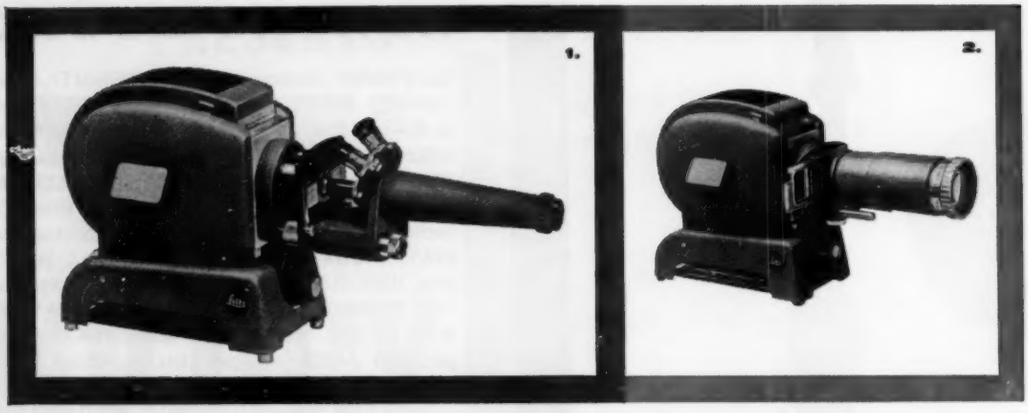

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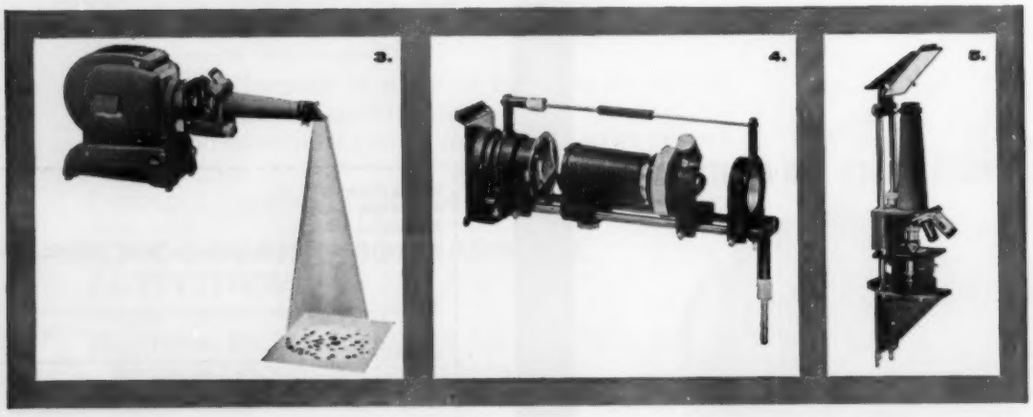

Identification of the Intellectually Gifted

By FREDERICK B. DAVIS

Professor of Education, Hunter College, New York City

EVERYONE recognizes that outstanding human talent is displayed in a wide variety of forms. Talented performers on musical instruments and in various psychomotor skills, such as figure skating, are as truly gifted as are the intellectually superior in the sense that they surpass in their own fields of talent the performance of as large a proportion of the population as do the intellectually gifted in their specialized fields of endeavor.

The social value or importance of outstanding talent varies from field to field and even from one kind of specialization to another within the same field. Without trying to establish the relative importance to society of the many kinds of talent that can be identified, we can all agree that intellectual giftedness ranks high in the list. From this it follows that identification of intellectual giftedness in children at an early age is socially desirable so that opportunities to develop their talents can be provided for them and further stimulated.

To accomplish this, two studies have been carried out at the Hunter College Elementary School in cooperation with the U. S. Office of Education.[1] The first of these included the development of two parallel forms of a differential aptitude test for gifted children 5-7 years of age. This test, called the *Hunter Aptitude Scales for Gifted Children,* was administered to 110 applicants for admission to grade one of an Elementary School. The results showed that children of outstanding ability in each one of five different areas of intellectual giftedness can be identified at early ages. These areas are: Word Knowledge, Number Facility, Logical Reasoning, Space Conceptualization, and Scientific Information. The average intercorrelation of scores in these five areas was only .44 (even though the average reliability coefficient of the tests was approximately .90), indicating that a child gifted in one area is by no means likely to be gifted in all of them or even in as few as two or three of them.

For example, in one group of 57 applicants for admission to the Hunter College Elementary School, the highest seven children in each of the five areas tested were listed. None was in the top 7 in five areas; two were in the top 7 in four areas; two were in the top 7 in three areas; five were in the top 7 in two areas; and eleven were in the top 7 in only one area. Out of 57 children, 20 were found in the top 12 per cent of the group in one or more of the five abilities tested. These data illustrate how intellectually gifted children can be identified if highly reliable tests of different aspects of mental ability are used. It may be noted in passing that such tests must be long (in order to attain high reliability), and they must be carefully constructed in such a way that the same mental skills will not be measured over and over again under different names.

Currently, data are being obtained to determine the usefulness of the Hunter Aptitude Scales for Gifted Children for predicting a child's later performance in different kinds of school work.

The second study included the construction of two parallel forms of a longer and more adequate test of science ability than was included in the Hunter Aptitude Scales for Gifted Children.[2] This study was designed to determine the effectiveness of a test of science ability for predicting the achievement of pupils in the third-grade science course given at the Hunter College Elementary School. The two 91-item forms of the test were administered in September 1959. The scores of the pupils were kept strictly confidential. During the course of the school year, seven achievement tests (including 215 items) were constructed to measure the subject matter taught in the science course. A composite score, weighted to correspond to the amount of time devoted to each of the seven units of work in the course, was obtained for use as a criterion measure. The correlation of the science-test scores with the criterion scores for the 58 pupils who completed the course was about .65, essentially as high as could be obtained given the reliability coefficients of the two scores. It is interesting to note that scores on the Stanford-Binet Scales, a well-known test of general intelligence administered to the same children considerably in advance of the science test, displayed a correlation with the composite-score criterion measures of only about .20. These data are in agreement with those obtained in previous studies which have shown that specially constructed tests are likely to be much more efficient for prediction purposes than existing tests of general intelligence so far as is known.

Additional investigations of the identification of intellectually gifted children have been planned and will be carried out in the Hunter College Elementary and High School as funds and personnel become available for the purpose.

[1] F. B. Davis, G. S. Lesser, E. G. French, *et al.* "The Identification and Classroom Behavior of Gifted Elementary-School Children." *The Gifted Student.* OE 35016. Monograph No. 2. U. S. Office of Education, Department of Health, Education, and Welfare. Order from Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. 1960.

[2] G. S. Lesser and F. B. Davis. "Identification of Gifted Elementary School Children with Exceptional Scientific Talent." (Mimeograph copy of 58 pages.) Hunter College, New York. 1960.

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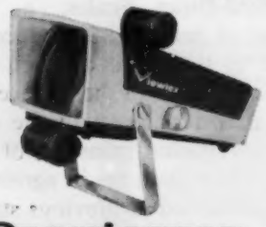

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Laws of Ampere and Oersted

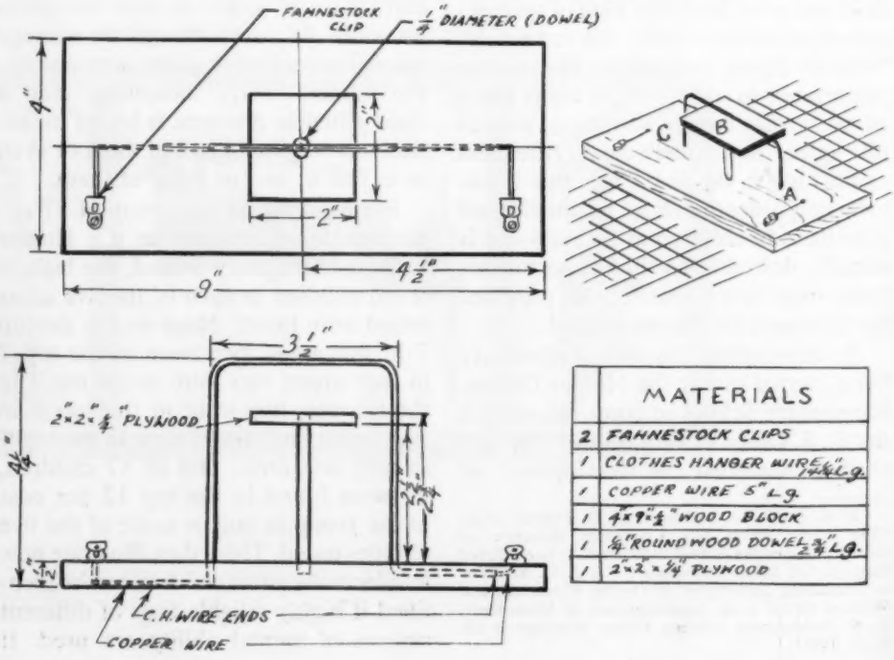
By BROTHER HUGH HAGGERTY, C.S.C.,
Vincentian Institute, Albany, New York

One look at the price of a commercial apparatus for the demonstration of the Laws of Ampere and Oersted will make the budget-conscious physics teacher a little hesitant at such an investment, especially when the allocation could be spent on modern electronic equipment. The method of procedure recommended in laboratory manuals has certain obvious drawbacks which the experienced teacher has, no doubt, encountered in the use of copper wires. Hence a simple, inexpensive, but valuable piece of apparatus can be constructed from scrap wood, a coat hanger, and short pieces of copper wire. The apparatus can then be used for teaching classes these two important laws which must be understood.

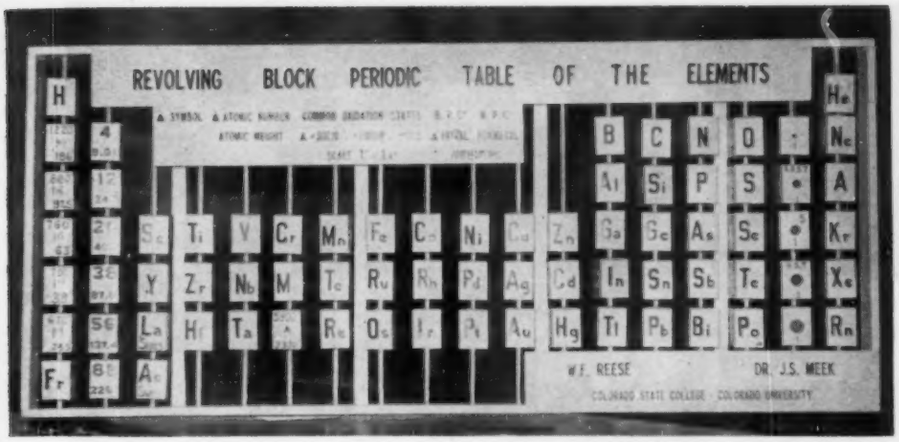
Soft wood is recommended for the base, and plywood for the platform (see Figure 1). The dowel rod is glued to the platform but not to the base. This makes the platform removable and gives the student more room to study Ampere's Law in Section C once he has completed Oersted's Law in Sections A and B. Plastic wood may be used to fill the groove in Section A when the coat-hanger wire, which has been bent to the shape indicated, has been placed in position. The short pieces of copper wire, soldered to the coat-hanger wire, make the final assembly to the Fahnestock clips, and the project is complete.

FIGURE 1.

ROBERT D. BREW, SIENA COLLEGE, LOUDONVILLE, N. Y.



	MATERIALS
2	FAHNESTOCK CLIPS
1	CLOTHES HANGER WIRE, 9" LG.
1	COPPER WIRE 5" LG.
1	4"×9"×1/4" WOOD BLOCK
1	1/4" ROUND WOOD DOWEL 2 3/4" LG.
1	2"×2"×1/4" PLYWOOD



Chemistry

The First Revolving Block Periodic Table

By WILLARD F. REESE, University of Alberta, Edmonton, Canada, and JOHN S. MEEK, University of Colorado, Boulder, Colorado

Every teacher has probably noted the difficulty encountered by beginning science students in comprehending the facts shown on a typical two-dimensional periodic table. These periodic tables are either incomplete—a fault that necessitates the use of two or more types of tables and makes correlation of facts difficult—or they are all-inclusive, resulting in a mass of data crowded on the small two-dimensional surface. The revolving-block periodic table is designed to supplement the typical classroom table and to point up graphically the periodic relationships of the elements.

In the model pictured, blocks were mounted on dowels in such a manner that each block could be turned individually or as a group when the dowel of the family was rotated.

The manipulation of the blocks permits the data to be shown on each of the four sides. The first side, for instance, has the symbol of the element. The second side shows the common valences of the element and the size of the atom on a one-inch per angstrom scale. The size is represented by the disc. If the element is a solid, blue is used; liquids are coded in green and gases in red. In the photograph, the halogens have this second side exposed. On the third side the atomic number and atomic weight are shown. The blocks representing the alkaline earths are shown in the photograph. The fourth side carries the characteristic chemical symbol along with the melting point and the boiling point of each element. Some of the alkali metals have their blocks turned so as to display this side during a discussion.

It has been found that students are stimulated to study the periodic table and drill themselves by rotating the blocks to find the answers to such questions as: How many of the elements are gases? How many are liquids? Can you predict the melting point of francium which is not yet shown? Can you guess that of potassium? What is the element related to chromium and molybdenum whose melting point is the highest of all known metals and has a common everyday use as a result of this property? Do atomic sizes increase or decrease in going from carbon to fluorine? Why? What are the valences of the alkaline earths?

The construction of a revolving-block periodic table is suitable also for a science club project. In addition to actually building the table, the students can be asked to give short talks on the history, discovery, and naming of the elements; the methods used to determine the size of atoms; and the ways of determining valences, atomic weights, and other data included on the blocks. The club could decide to delete or add to the information shown on their periodic table. For example, the table could include the electronic configuration of each element, perhaps shown with the symbol on the first side. The rare earths and actinides could also be included.

Any teacher desiring additional information on this subject may write to the co-author, Dr. Reese.

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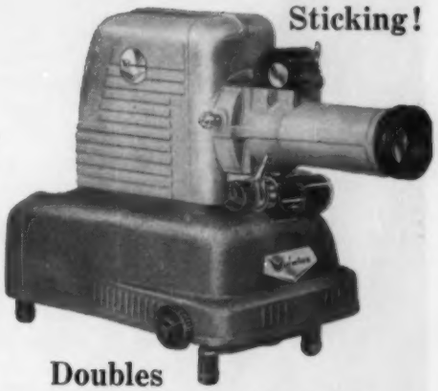

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Earth Science

Coriolis Force

By JOHN LYMAN, National Science Foundation, Washington, D. C.

Newton's Laws of Motion, applied to the graphic information derived by combining some readily available household articles, can be made to yield both a convincing demonstration of the reality of *Coriolis Force* and a quantitative basis for deriving a formula for it.

The following materials are needed:

1. An electric train. I used an S-gauge train, but an O-gauge or especially an 027-gauge would be even better in view of the smaller table top required to make a circle. An HO-gauge train is probably too delicate for the operation. Any of these trains will have speed control through transformer and a locomotive that is readily reversible. Only the locomotive and transformer are needed, with enough track to make an oval having two or three straight sections.

2. A three- or four-speed phonograph. It must have a tone arm that can be retracted far enough to permit an outrigger from the train to sweep as far as the middle of the turntable without interference.

3. A supply of corrugated cardboard sheets, cut to the size of a 12-inch phonograph record.

4. A couple of felt-tipped marking pens ("Magic Marker," "Draws-a-Lot," etc.) in contrasting colors.

5. A pair of small corks, a wire coat hanger, Scotch tape, a knife, and pliers.

Trim the corks so that they will fit snugly into opposite windows of the locomotive cab. From the coat hanger, fashion a piece of wire with an eye in one end to hold one of the marking pens and a straight length sufficiently long to reach through the locomotive cab and past the center of the phonograph turntable. Secure this wire to the locomotive by passing it through the corks, as shown in Figure 1.

Now, position the phonograph next to a straight portion of the track. Adjust the height of the phonograph (pieces of the corrugated cardboard under it are useful for fine adjustment) and the curvature of the outrigger wire until the locomotive will carry the pen in such a way as to make a neat straight line across a piece of the cardboard on the motionless phonograph turntable.

You are now ready to start taking data. I found it useful to call for some volunteer geophysicists from the class—a qualified operating engineer to run the transformer, a musician to operate the phonograph, and a display artist to hang the cardboard discs as they are produced on the top of the blackboard with Scotch tape. The badge of authority, the second marking pen, is retained by the instructor to add annotations of speed and rpm to the records along with an arrow indicating the direction of motion of the pen.

Two primary data series should be taken with this equipment. First, holding the train speed constant as it goes through the straight stretch, vary the turntable speed from 78 down to 16½ rpm. Instead of the straight line that it drew when the turntable was motionless, the pen now draws a series of curves like those in Figure 2(a) and (b).

Then, with a moderate rate of rotation, take a second series with train speed as the variable. Results will look like Figure 2(b), and the spectrum of speed can be expanded by reversing the direction of the train.

It is not possible to reverse the direction of rotation of an AC phonograph (unless there happens to be a belt drive, in which case the belt can be varied between a figure-eight and an oval); but a DC phonograph can be reversed by reversing the leads from the batteries. In the absence of either of these means

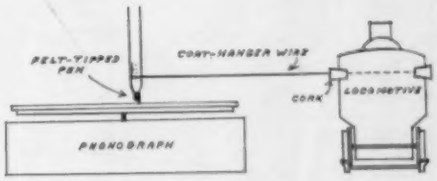


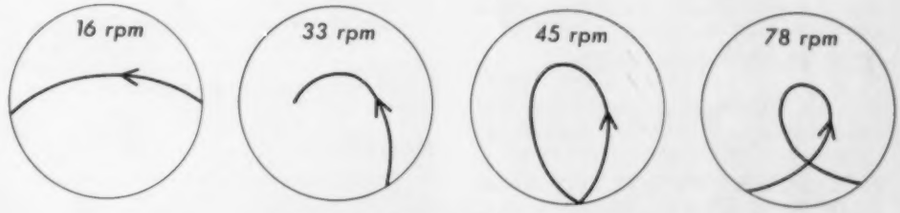
FIGURE 1.

of obtaining an actual record during counter-clockwise rotation of the turntable, the class can be asked to consider what would happen if the pen arm were arranged so as to permit two pens to mark both sides of the turntable simultaneously.

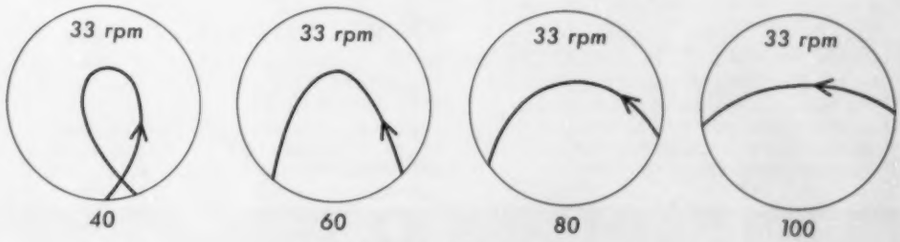
It is clear that in this event the trace on the lower side would be the mirror image of the upper trace, *i.e.*, the deflection would be to the right of the direction of movement of the pen, instead of to the left as it invariably is when the turntable rotates in its normal clockwise direction. Viewed from the lower side, the turntable has counter-clockwise rotation, just as the Earth has when viewed from the Northern Hemisphere.

The rotating turntable is thus a model of our Earth—flattened at the poles much more than in nature—and its clockwise rotation corresponds to the Southern Hemisphere. The straight train tracks, and therefore the motion of

FIGURE 2.



(a) TRAIN SPEED CONSTANT (50)



(b) TRAIN SPEED VARIABLE

NOTE: The author is Associate Program Director for Earth Sciences (Oceanography) at the National Science Foundation.

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the pen which they constrain, correspond to particle trajectories fixed with respect to the stars and independent of the coordinates of the rotating earth. But on this earth such a straight trajectory becomes a complex curve, with deflection always to the left of the direction of motion in the Southern Hemisphere and to the right in the Northern.

We can now introduce Newton's Laws of Motion. The First Law states that any body persists in a state of rest or of uniform motion in a straight line unless a force is imposed to change that state. But we have just found that the motion of the pen over the turntable is a straight line only if the turntable is not turning. As soon as there is any angular rotation of the turntable, the motion of the pen relative to it is in a curved path. Therefore, introduction of angular rotation to the turntable also introduces a force that causes the pen to make a curved trace.

How great is this force? We can answer this question through application of the Third Law of Motion which tells us that for any action there is an equal and opposite reaction. Although the pen traces a rather complex curve, any short portion of it can be represented with reasonable precision by a circle of appropriate radius. A body of unit mass moving in a circle or radius r at speed v is acted upon by a centrifugal force away from the center equal to v^2/r. The force toward the center that we are seeking is also v^2/r.

What have we learned about the variation of r ? The results of Figure 2(a) show at once that r varies inversely with angular velocity ω and Figure 2(b) shows that r is proportional to speed v. It is clear also that we have the greatest curvature (smallest r) at the axis of the turntable. That is considering the spheroidal earth, r is smallest at the poles. It does not become infinitesimally small, however, as the curvature of the trace varies smoothly if the pen passes directly over the axis, and it does not show a cusp. In a similar manner, since we have already deduced that our force changes from right-handed force in the Northern Hemisphere to the left-handed in the Southern Hemisphere, it follows that the force must vanish at the Equator. No curvature of a path exists at the Equator, which is the same as saying that the Equator has infinite radius of curvature. The cosecant of the latitude (ϕ) meets the specification of a

quantity that varies from infinity at the Equator to a minimum but finite value at the Pole.

We have thus established that r is directly proportional to v and $csc\ \phi$ and inversely proportional to ω; or introducing a constant of proportionality k, we can write

$$r = kv \csc \phi/\omega.$$

Substituting this expression for r in the relationship for the deflecting force of the Earth's rotation that we previously deduced, we have for unit mass:

$$\text{Deflecting Force} = v^2/r = \omega v/k \csc \phi = \omega v \sin \phi/k.$$

The constant k as here written turns out to have the value of ½, and this expression thus becomes identical with the equation for Coriolis Force:

$$F = 2\omega v \sin \phi.$$

NSTA CALENDAR

As a regular feature of *The Science Teacher*, the calendar will list meetings or events of interest to science teachers which are national or regional in scope. Send your dates to *TST*'s calendar editor as early as possible.

April 10-14, 1961: 45th Annual Meeting, Federation of American Societies for Experimental Biology, Convention Hall, Atlantic City, N. J.

June 22-24, 1961: NSTA Regional Conference, University of Hawaii, Honolulu

July 7-9, 1961: Annual Business Meeting of Board of Directors, NEA Building, Washington, D. C.

August 25-26, 1961: NSTA Regional Conference, University of Utah, Salt Lake City

September 4-5, 1961: NSTA Regional Conference, Oklahoma State University, Stillwater

September 8-9, 1961: NSTA Regional Conference, University of North Carolina, Chapel Hill

September 22-23, 1961: NSTA Regional Conference, University of Nebraska, Lincoln

September 28-30, 1961: NSTA Regional Conference, Vocational High School, Minneapolis, Minnesota

October 6-7, 1961: NSTA Regional Conference, Bradford Hotel, Boston, Massachusetts

October 13-14, 1961: NSTA Regional Conference, Netherland Hilton Hotel, Cincinnati, Ohio

October 13-14, 1961: NSTA Regional Conference, Sheraton Hotel, Portland, Oregon

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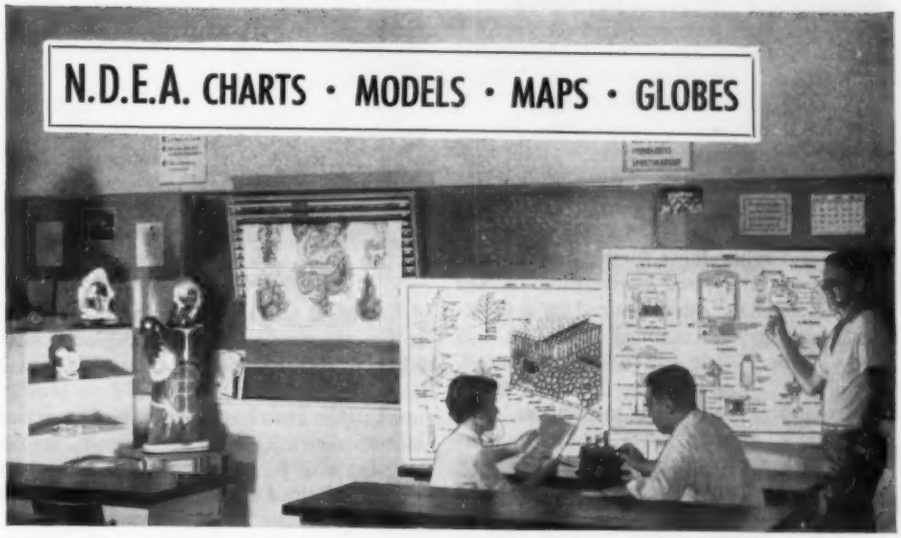

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Regional Conferences, 1961

In response to the increasing extent and intensity of interest in professional meetings for science teachers, NSTA has scheduled ten regional conferences for the period June through December 1961. Although the programs for these conferences are being developed by local and regional committees, similarities in purposes and relatedness to the national endeavor (as the 1962 convention in San Francisco) have been assured by a three-day planning session for all chairmen held last October 7-9 in Chicago. In general, the all-pervading theme or focus of attention will be "the learner in science." The schedule of these regional conferences is given below, together with detailed reports of the first three meetings.

June 22-24. Honolulu, Hawaii. *Chairman:* Teruo Masatsugu, Department of Public Instruction, P.O. Box 2360, Honolulu.

August 25-26. Salt Lake City, Utah. *Chairman:* LaVar L. Sorensen, Salt Lake City Schools, 440 East First South Street, Salt Lake City.

September 4-5. Stillwater, Oklahoma. *Chairman:* Lucile Berlin, Tulsa Public Schools, 2829 South Peoria, Tulsa 14.

September 8-9. Chapel Hill, North Carolina. *Chairman:* John B. Chase, Jr., School of Education, The University of North Carolina, Chapel Hill.

September 22-23. Lincoln, Nebraska. *Chairman:* James A. Rutledge, University High School, University of Nebraska, Lincoln 8.

September 28-30. Minneapolis, Minnesota. *Chairman:* J. Hervey Shutts, Minneapolis Public Schools, 807 N.E. Broadway, Minneapolis.

October 6-7. Boston, Massachusetts. *Chairman:* Ralph E. Keirstead, State Department of Education, P.O. Box 2219, Hartford, Connecticut.

October 13-14. Cincinnati, Ohio. *Chairman:* Kenneth E. Vordenberg, Cincinnati Public Schools, 608 East McMillan Street, Cincinnati 6.

October 13-14. Portland, Oregon. *Chairman:* John S. Hutchinson, Portland Public Schools, 631 Northeast Clackamas Street, Portland 8.

December 27-30. Denver, Colorado (annual meeting with the American Association for the Advancement of Science, and other science teaching societies). *Coordinator:* Sam S. Blanc, Gove Junior High School, Denver.

Meeting in Hawaii

"Toward Quality Teaching in Science" is the theme for the first regional conference to be held in Hawaii (fiftieth State of the Union) at the Hilton Hawaiian Village Hotel and at the University of Hawaii, June 22-24, 1961. This three-day meeting will precede the regular summer session of the University of Hawaii, thus enabling the participants to take advantage of courses at the University, if interested.

A maximum of 700 participants has been set and well over 500 elementary and secondary teachers, supervisors, and administrators of Hawaii have already indicated their interest. Science teachers and others from the remaining forty-nine states, especially those in California, Washington, and Oregon are cordially invited to attend. For information and reservations, write to Terry Masatsugu, *Chairman,* Hawaii Regional Conference, P. O. Box 2360, Honolulu 4, Hawaii.

Program

General Sessions: Addresses on "Toward Quality Teaching in Science" and "The Impact of Science on Society."

Concurrent Session, Elementary: On Oahu, 20 interesting field trips; 20 workshops in different subject areas; "Here's How I Do It" sessions; addresses on "Problems and Practices in Elementary Science"; and "How to Conduct Experiments."

Concurrent Session, Secondary: Presentations and discussions of programs in physics (Physical Science Study Committee), chemistry (Chemical Education Material Study and Chemical Bond Approach), biology (Biological Sciences Curriculum Study), and general science (Earth Science); subject area meetings on the techniques and uses of scientific instruments; demonstrations in biology, physical science, and general science.

Exhibits: Science supply houses, audio-visual companies, and publishing companies.

Films: Showings of elementary science, biology, chemistry, physics, and general science films.

Socials: Two luncheons and one banquet (Chinese dinner).

Resource People: Robert A. Rice, president, NSTA; J. Arthur Campbell, Director, CHEM; Kent Wilson, Director, CAB; Arnold Grobman, Director, BSCS; Albert Piltz (tentative), Specialist in Elementary Science, U.S. Office of Education; Kenneth Davis, PSSC; Walter Thurber (tentative), Elementary Science, Syracuse University; members of the Hawaiian Academy of Science and the University of Hawaii Science Department for workshops and demonstrations.

Rocky Mountain Meeting

The Rocky Mountain Regional Conference, second meeting of the year, will be held in Salt Lake City, Utah on the University of Utah campus, August 25 and 26, 1961. Teachers from Utah, Idaho, Nevada, Arizona, Wyoming, and Colorado will participate. The theme of the meeting is "Learning Science, an Individual Process." The various sessions are planned to focus attention on "the learner" and promise to provide a challenging discussion for science teachers at the elementary, secondary, and college levels.

Among other nationally prominent scientists and educators will be Calvin W. Taylor, professor of psychology at the University of Utah. Dr. Taylor organized and was principal investigator of the 1955, 1957, and 1959 national research conferences, supported by the National Science Foundation grants, on "The Identification of Creative Scientific Talent." Panel discussions featuring students, or "learners," and led by psychologists working with Dr. Taylor, will also be included in activities of the first day.

A banquet is planned for the evening in the spacious air-conditioned ballroom of the new Student Union Building on campus. Guest speaker will be Henry Eyring, world-renowned chemist and dean of the graduate school, University of Utah.

The "Here's How I Do It" sessions, which will include various subject areas, have been arranged for the morning of the second day. All grade levels will be covered in these demonstrations by out-

standing teachers in the various subject areas. Presentations will also be given by directors and consultants on three national research studies: the Physical Science Study Committee (PSSC), the Biological Science Curriculum Study (BSCS), and the Chemical Education Material Study (CHEM).

Science teachers attending the conference can register Wednesday evening, August 24, at 7:00 p.m. and again Thursday morning, August 25, at 7:30 a.m. in the foyer of Orson Spencer Hall where the sessions are to be held. The entire housing facilities on the campus of the University will be available to persons attending. Arrangements must be made through Lewis E. Haines, director, Office of Housing. For other information, write LaVar L. Sorensen, *Chairman,* Regional Meeting, National Science Teachers Association, 440 East First South, Salt Lake City, Utah.

South Midwestern Meeting

"The Learner and Science" is the theme of the third regional conference to be held at Oklahoma State University, Stillwater, on September 4-5, 1961. Dr. Darrell Barnard, President-elect of NSTA will represent the Association. Science teachers from Arkansas, Kansas, Missouri, New Mexico, and Oklahoma, as well as those from other states are invited to participate. If the vast effort toward the improvement of the program of science education in elementary and secondary schools is to count, it becomes imperative that the needs and interests of the individual learner be recognized and studied. To meet these needs and interests many things are required: well trained and competent teachers; sound and inspiring approaches to learning; and carefully selected and appropriate materials and facilities. Ralph E. Keirstead put it this way: "The uniqueness of the learner and his learning process requires insofar as possible and practicable, unique educational procedure specifically designed to serve him."

Registration begins on Monday, September 4. "Significant Values of Scientific Research of Elementary and Secondary Science," the keynote topic will define, in part, this unique educational procedure which we seek. The Discussion Orientation Program on this day will include Curriculum Structure and Development of the K-12 Program in Science; Approaches to Learning in Science; Laboratory Experiences and Learning in Science; Selection, Use, and Storage of Materials and Equipment; Better Use of Communication Media in Science Learning; Science Related Activities; Science Club, Science Fair, and Academy of Science. The Luncheon Meeting topic, "The Need for and the Value of Professional Organizations," will supply the opportunity to study the role of leadership exerted by the NSTA in the field of elementary and secondary science education. That evening at the Banquet Program the "Frontiers in Science" discussion will take us into the tip of the arrow as it penetrates the unknown areas of the world in which we live. This look ahead is essential if we are to be prepared to meet the world of tomorow.

Planning Committee for Regional Conferences: (l. to r., First Row) Chase, Keirstead, Hutchinson, Masatsugu, and Rutledge. (l. to r., Second Row) Sorensen, Betty Simendinger (1962 Convention Chairman), Barnard (NSTA President-elect), Berlin, Shutts, and Joseph De Pollo (representing Vordenberg).

The second day, Tuesday, September 5, will include Tours, Films, "How-To-Do-It" sessions, discussion group activities, and a final conference summary session to review the results of the conference. Each participant will have an opportunity to evaluate the contributions of the conference and to deliberate on the final outcome or make recommendations based on the discussions.

The Keynote Session, Luncheon, Banquet and Conference Summary Sessions will be held in the air-conditioned Student Union Building on campus. Exhibits totaling about 35 will also be displayed there. The Tours will include visits to the Nuclear Reactor; Nuclear Physics Laboratory; Radio-chemistry Laboratory; Biochemical Research Facilities; Biological Radiations Research, Radioisotopes, and Radiation Laboratory; Computing Center; and Science Department Laboratories.

Housing at the Union Club will accommodate near 200 persons. The cost is about $4 per day. Also available are the University dormitories which will take care of 300-500 persons at a cost of $1.50 per day. For housing arrangements write to Robert Fite, Oklahoma State University, Stillwater, Oklahoma.

Chapters and Affiliated Groups

Final approval has been accorded to criteria and procedures proposed for the enrollment of chapters of NSTA and for the continuation or enrollment of affiliated groups. Steps toward this goal have included authorization by the NSTA Board of Directors (see October 1960 *TST*, p. 45), study and recommendations by a special committee, field conferences involving many persons and groups, and finally, review and approval by the Executive Committee. Copies of the plan have gone to presidents of all groups currently affiliated with NSTA, about seventy-two in all. Several state groups have already taken action to "put on another hat" and consider themselves as chapters of NSTA. State, regional, or national groups that

Research Fellowship

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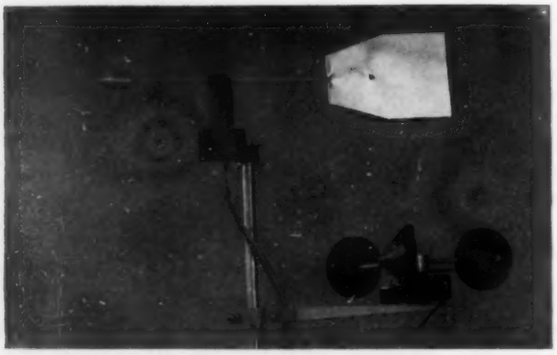

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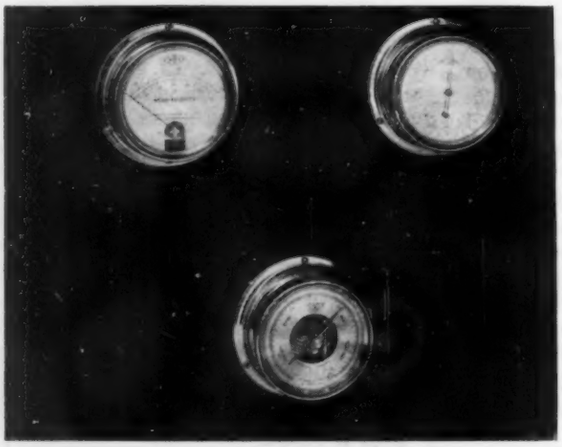

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EXAMINATIONS COMMITTEE—ACS
University of South Florida
Tampa 4, Florida

may not have been reached directly are hereby invited to seek more information from NSTA and to give consideration to joining this movement to strengthen further the voice of science teachers in America.

FSAA, 1961

About 198 students scattered throughout the country are being advised daily of their success as winners of regional awards in the 1961 (tenth annual) Future Scientists of America program of Science Achievement Awards. Also, 2000 others will receive honorable mention certificates. Judging committees in the eleven geographic regions have been reviewing a total of some 6000 entries and promise to have the results ready to report by mid-April. Meanwhile, efforts are under way to enlarge the program and widen its sponsorship for 1962 and ensuing years. Conferences have been held with representatives of more than thirty scientific and engineering societies, several among which have already indicated a desire to become co-sponsors of the FSAA awards program. As is well known, the American Society for Metals initiated the program in 1952 and was the sole sponsor through 1960, investing a total amount of approximately $160,000 in this effort to help produce tomorrow's scientists, engineers, and other technically trained personnel.

FSA Organization

The first year of FSA is drawing to a close. Success seems to have crowned the efforts of all concerned. More than 700 FSA chapters enrolling in excess of 20,000 students have been installed since October. Chapter sponsors and all NSTA members are reminded that charter fees and annual dues cover only part of the costs involved in providing FSA services and materials. Contributions by business-industry organizations go a long way to make the program possible. Contributions to FSA and other facets of the total NSTA program since the last listing (November 1960 *TST*) are as follows:

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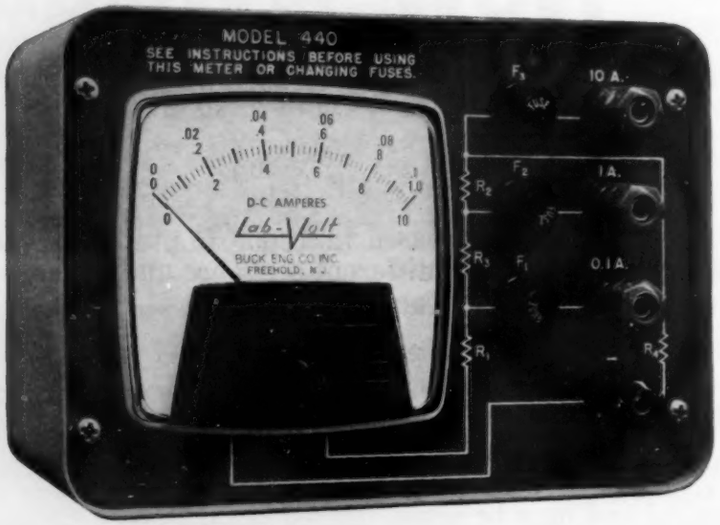

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International Activities

Youth Science Study Tour

Selection has been made of Millard Harmon as leader of the Youth Science group of five students attending the Third International Youth Science Fortnight in England, July 21-August 4. Mr. Harmon has taught for two years in the U.S. Armed Forces school in West Germany, and is currently teaching in the Newton, Massachusetts public schools. It is expected the event will attract about 600 students, aged 16 to 19, from fifteen different countries along with our group. The program will consist mainly of addresses by eminent British scientists, "brain trust" panels, discussions by the students, visits to scientific museums, laboratories, and historic spots, and various social and recreational activities. During the continental tour, visits will be made to places of special interest to science students as well as to other cultural attractions.

Millard Harmon

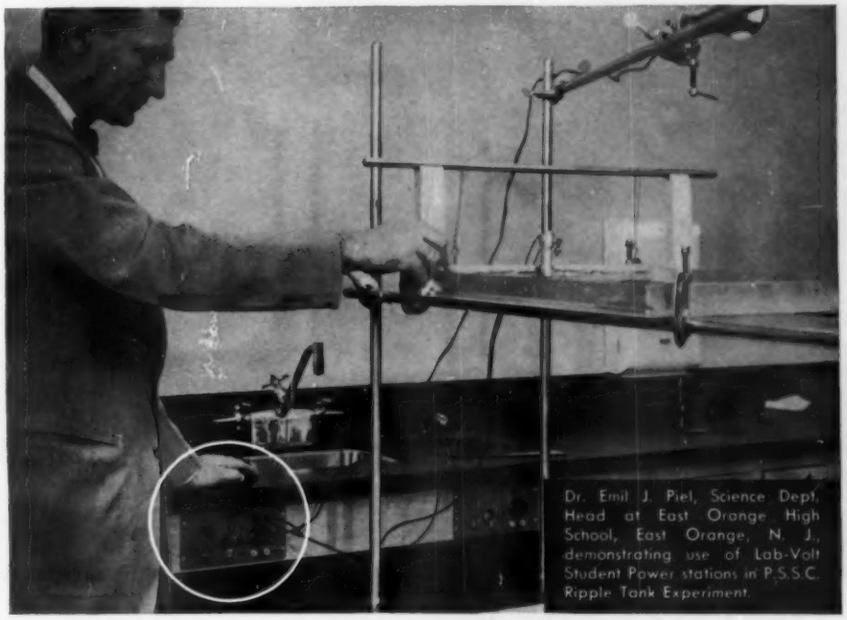
A pilot-run international youth activity for NSTA, this venture has been made possible by a grant from Scholastic Magazines, Inc., publisher of *Science World*. The money will be used to provide travel scholarships of $350 each for the five students and to cover expenses for an adult leader who will accompany the group.

Should this undertaking prove successful, every effort will be made to continue and enlarge the program. It may become an annual event under the Future Scientists of America program and thus enable us to widen the opportunity for qualified youth to take part in International Youth Science Study tours.

Teacher Science Study Tour

The complete report of NSTA's 1960 European Science Study Tour for teachers is now available. Comprised of more than 20 separate accounts of conferences, places visited, and other tour features, the publication gives invaluable insights into science and science teaching as observed in Scotland, England, and five Western European countries. It is priced at fifty cents to cover costs of duplication and mailing. Order directly from NSTA; *only prepaid orders accepted.*

EDITOR'S NOTE: The name of the school under the byline heading under author J. Joel Berger was inadvertently picked up in the February 1961 issue, page 15. Mr. Berger is a science teacher at the Lafayette High School, Brooklyn, New York. (See article "Developing Concepts in High School Chemistry.")


Dr. Emil J. Piel, Science Dept. Head at East Orange High School, East Orange, N. J., demonstrating use of Lab-Volt Student Power stations in P.S.S.C. Ripple Tank Experiment.

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Julius Sumner Miller, Professor of Physics at El Camino College, California, came to Cenco with ideas for four proved teaching devices which would stimulate student interest and demonstrate important laws in physics. Cenco engineers, in collaboration with Professor Miller, have designed and developed these new devices . . . a thermal expansion apparatus . . . a temperature coefficient of resistance apparatus . . . a rocket propulsion demonstrator . . . and a triple track inclined plane. These teaching aids fit into any physics course. They are sturdily built for student use and of large dimensions for lecture demonstration. Professor Miller is typical of scientists in both the teaching profession and in industry who come to Cenco and find a cooperative atmosphere for the development of new ideas. This is another example of new laboratory instruments from Cenco to aid in teaching the fundamentals of science.

New Miller devices: Thermal expansion apparatus No. 77430, $49.50 (top left); temperature coefficient of resistance apparatus No. 83064, $37.50 (bottom left); propulsion demonstrator No. 76176, $29.50 (top right); triple track inclined plane No. 74870, $69.50 (bottom right).

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BOOK Reviews

The Intelligent Man's Guide to Science. Isaac Asimov. Volume I, *The Physical Sciences,* 388p. Volume II, *The Biological Sciences,* 464p. Set $15. Basic Books, Inc., 59 Fourth Ave., New York 3, N. Y. 1960.

The reviewer classifies these as superb books. From the gentle flattery of the title to the not-so-gentle expedition into relativity and the structure of organic molecules, they delight the eye and cultivate the mind. He says: "I began as a skeptic and emerged as a convert." As a genuine layman, he was uncertain that he could be made to understand the growth and grandeur of science. Yet Mr. Asimov attempts this very goal and at least one reader is convinced that he succeeds.

True, there were times says the reviewer "when he lost me, but with hard work I was usually able to catch up again." It was difficult to see how the parallax of Venus was calculated by measuring from various points in Europe the time it took to cross the face of the sun. But Mr. Asimov has chosen his "toughies" with skill. He takes his reader by the hand and shows him, step by step, some of the rational developments which have brought mankind to an unprecedented power to understand, predict, and act.

J. Robert Oppenheimer holds that the frontier of science is so distant from the nonscientist that he can never understand the nature or the excitement of scientific inquiry; even scientists in other fields cannot understand. This intellectual privatism bothers me. Not that I pretend that laymen like myself can accompany such scientists. But it seems reasonable that any science must develop a kind of generalized insight, a view of the world, and that it should not take years of study to acquire at least some understanding of that insight and how it was obtained. Take, for example, the astronomer's view of space. An educated man today must understand this view, he must comprehend the minuteness of the solar system and of the earth. He must see man as the speck he is, poised on a grain of sand in a galaxy which is itself lost in the galaxies of galaxies.

How did man learn that he is not the center of the universe, the lord of creation? Maybe the student does need more mathematics than that of the average layman to know the answer to the question. Mr. Asimov, however, provides a lot of help and insight. It is possible to understand the logic of the parallax (Halley's computations on Venus aside), and to see how the magnificent research on the Cepheid Variables led to the rational development of new concepts of distance. Leavitt and Shapley and Hubbell make sense to me now. I am no astronomer, but I am better educated than I was.

Dr. Einstein is more comprehensible now. To one whose roots are in Newtonian physics, it seemed impossible that any human mind could have developed the strange concepts of relativity. The mathematics of relativity are still out of reach. But the Lorentz-Fitzgerald equations and the seminal contributions of Max Planck at least make Einstein's contributions seem human.

Reviewing these books has been an enjoyable task. A teacher of science who feels the need for a broad look at fields outside his specialties would do well to start here. A bright high school student would surely find profit in these pages. Parents who want their children to see the magic and mystery of science would do well to try these excellent volumes as an investment. If a wider general conception of science and its central role in our future were to result, we would have Mr. Asimov and his publishers to thank for an outstanding achievement.

JAMES E. RUSSELL
Secretary, Educational Policies Commission, NEA

The Lower Animals. Living Invertebrates of the World. Ralph Buchsbaum and Lorus J. Milne in collaboration with Mildred Buchsbaum and Margery Milne. 304p. $12.50. Doubleday and Company, Inc., 575 Madison Ave., New York 22, N. Y. 1960.

With 144 full color and 148 black-and-white reproductions of photographs of living invertebrates, this book is an artistic *tour de force*. But it is no mere picture book. The reputations of the authors for accurate and arresting presentation of biological information is furthered by the excellent and extensive text.

The aim of the authors is to introduce that vast array of animals which, because they have no backbones, are cavalierly lumped together by man as invertebrates. As the authors state: "The phrase 'spineless as a jellyfish' is meant to epitomize the flabby invertebrate way of life." Flabby, indeed. The invertebrates outnumber, outvary, and, while more ancient, may outlast the vertebrates. These fascinating animals, except for the insects, are presented phylum by phylum, class by class, from protozoa to protochordata.

In spite of limited space, the authors avoid producing a mere catalogue and present significant facts about the natural history of these beasts. The captions for the figures are in simple language. The text is more difficult. Many technical terms are used without interruption for definitions. "Common names" for groups and species are usually supplied, but scientific names are used unflinchingly. In other words, there is no writing-down to a presumed level of ignorance. The result should be satisfying to biologists.

Except for the pictures, the book is not likely to become a popular bedtime companion. In the preface, the authors note that recent developments in photography and skin-diving allow an unprecedented chance to observe marine life, which is predominantly invertebrate. This book should educate and encourage devotees of these activities. It should also give information and pleasure to naturalists who appreciate the kaleidoscopic colors, fascinating forms, and amazing habits of the animals which have succeeded without backbones.

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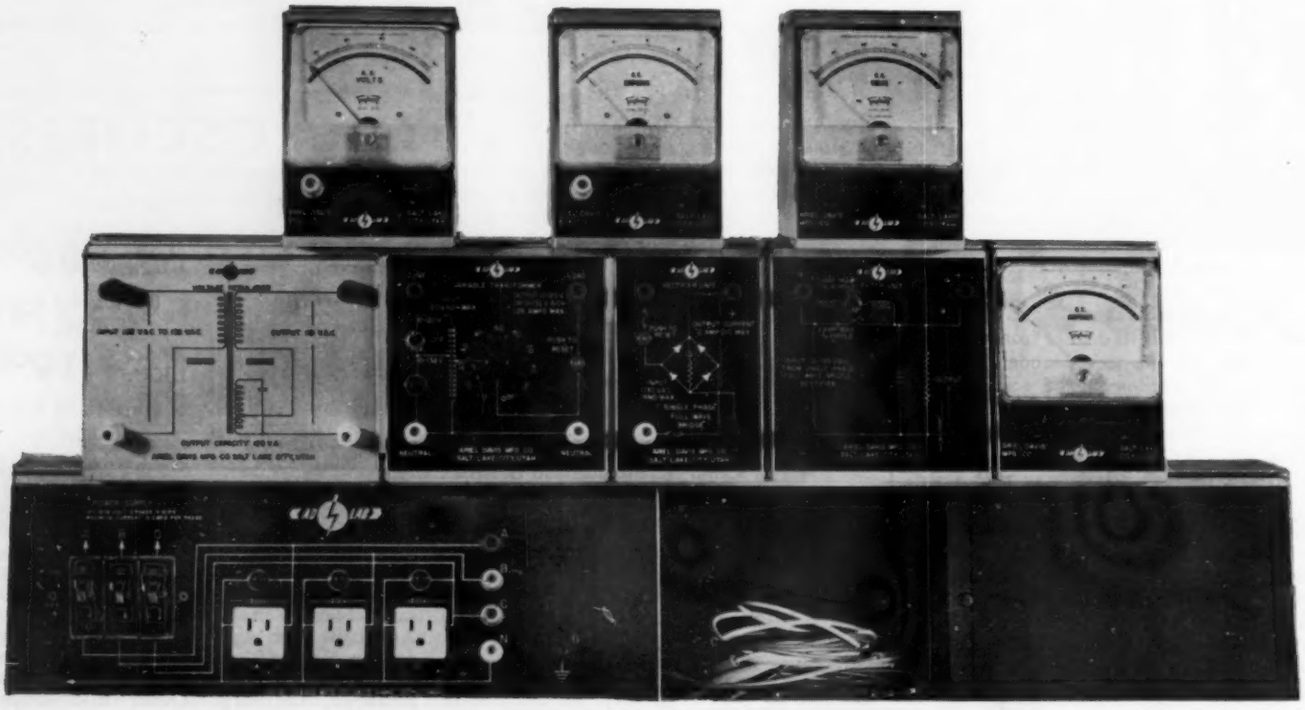

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Chairman: Dr. H. Seymour Fowler

The Pennsylvania State University, University Park, Pennsylvania

BOOK BRIEFS

All About Undersea Exploration. Ruth Brindze. 146p. $1.95. Random House, Inc., 457 Madison Ave., New York 22, N.Y. 1960.

Another "All About" book concerning earth's last frontier. Chapter headings include: The World beneath the Sea, Fathoming the Ocean's Secrets, Scientists at Sea, Helmet and Scuba Diving, Descent by Bathysphere and Bathyscaphe, Exploration by Submarine, Treasure Hunters on the Bottom, Underwater Photography, The Search for Oil beneath the Sea, Wiring the Oceans, and Earth's Last Frontier. More than sixty illustrations make vivid the historical progress of undersea exploration. Technical terms are well defined. Emphasizes that much is yet to be learned about the seas. Suggestions for further reading are given. This book has reading for both pleasure and information from the advanced elementary level through the junior high school.

The Earth beneath the Sea. Francis P. Shepard. 266p. $5. The Johns Hopkins Press, Baltimore, Md. 1960.

The author tries to make it possible for people with little technical knowledge in oceanography to understand and become familiar with such things as wave movement, coral reefs, the ocean bottom, and continental shelves. He brings to life the drama beneath the sea. Personal experiences are fused with a deep understanding of this subject to provide hours of fascinating reading which stimulates interest.

All About Fish. Carl Burger. 140p. $1.95. Random House, Inc., 457 Madison Ave., New York 22, N.Y. 1960.

One of the volumes in the "All About" series. Chapter headings are: What Is a Fish, Anyway?; In the Beginning, Sea Serpents and Monsters; Some True Fish Tales; Saltwater Fish; Freshwater Fish; Part-time Residents; Fish of the Coral Reefs; Fish for Dinner; Fish for Pets; and Fishing for Fun. Covers many of the outstanding points of ichthyology. Well written to stimulate an interest in this field among elementary and junior high age students. Excellent illustrations are also an asset.

Leadership for Science in the Elementary School. California Association for Supervision and Curriculum Developments. 88p. $2.50. 1705 Murchison Drive, Burlington, Calif. 1960.

A handbook for teachers, administrators, consultants, and supervisors that is a real contribution to the literature. It is a manual packed with practical ideas and prepared by educators who give of their personal experiences. These have been carefully evaluated and skillfully summarized to give the reader a thoughtful analysis in compact form. Includes suggested sources of further information and good in-service suggestions. Illustrated.

Dragonflies and Damselflies. Mary Geisler Phillips. 96p. $2.50. Thomas Y. Crowell Company, 432 Fourth Ave., New York 16, N.Y. 1960.

Chapter headings include: How to Name an Animal, The Dragonflies—Anisoptera, The Life of a Damselfly, Wing Veining and Odonata, In the Fields, and Preserving and Mounting Odonata. The morphology of the two suborders is clearly presented by text and excellent line drawings. Taxonomy, anatomy, and some ecology are described in a manner well-suited to the younger reader. The chapters which cover collecting and preserving specimens should be particularly helpful to the beginner. Addresses of several supply houses are given as well as an extensive bibliography and an index of the plants which appear in the illustrations. The book would be an asset to the biology teacher's reference shelf.

Careers and Opportunities in Science. Philip Pollock. 194p. $3.95. E. P. Dutton and Company, Inc., 300 Fourth Ave., New York 10, N.Y. 1960.

This rewritten version of an earlier edition, *Careers in Science*, by the same author, presents an excellent survey of the general characteristics and qualifications of scientists. Covers in detail career opportunities in physics, chemistry, atomic energy, geology, biology, medical research, and conservation. Also contains an excellent chapter outlining

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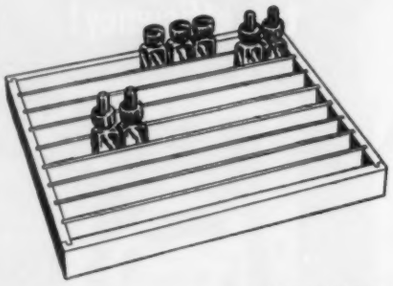

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scientific careers for women. Appendices include: salaries of scientists, lists of colleges and universities offering science courses, and science courses available in the armed services. Recommended for junior and senior high ages. Of value to science teachers and career counselors.

The Space Guidebook. William J. Weiser. 322p. $4.75. Coward-McCann, Inc., 210 Madison Ave., New York 16, N.Y. 1960.
A book with an unusual type of organization. Chapters are organized around pertinent questions about space and its exploration. Answers follow each question. This type of organization should stimulate students to think before reading the answer. Major topics outline the origin of the universe; the planets and other bodies in space; problems that man faces in conquering space; rocket, missile, and satellite development; and instruments used to study space. The appendix contains a biography of each astronaut, a box score of space probes, and a table of facts about the solar system. Useful for junior and senior high science classes.

Time for You. Duane Bradley. 110p. $2.75. J. B. Lippincott Company, East Washington Square, Philadelphia 5, Pa. 1960.
The author describes the development of the Julian and Gregorian calendars, as well as the concepts which underlie the Egyptian, Mayan, Greek, Japanese, and other systems of telling time. Written in clear, simple language and accompanied by many illustrations and diagrams, the story outlines one of man's most complex discoveries. Recommended for the upper elementary grades.

Pasteur and Modern Science. Rene Dubos. 160p. 95¢. Doubleday Anchor Books. Order from Wesleyan University Press, Inc., Columbus 16, Ohio. 1960.
Depicts the life and work of Louis Pasteur. Descriptions of his important discoveries are given. His work in crystallography, pasteurization, fermentation, and a host of other areas gives the reader an insight into Pasteur's amazing personality. Designed as a supplement to advanced biology or physiology courses on the high school level.

The Space Encyclopedia. Harold S. Jones *et al.* 288p. $8.95. E. P. Dutton and Company, Inc., 300 Fourth Ave., New York 10, N. Y. 1960.
A comprehensive volume which contains many definitions of "Space Age" vocabulary. Excellent diagrams or illustrations are used to supplement the more difficult concepts. Major areas covered by the book are astronomy, space medicine, rocketry, satellites, and space research. Recommended for junior and senior high school science classes.

Handbook of Chemistry and Physics. Forty-Second Edition. Charles D. Hodgman, Editor-in-Chief. 3482p. $12. The Chemical Rubber Publishing Company, Inc., 2310 Superior Ave., N. E., Cleveland, Ohio. 1960.
Probably every science teacher knows this as a complete reference covering mathematics, physics, and chemistry. In the forty-second edition many new tables are included, and regularly featured tables are brought up to date. The index is complete and easy to use. An authoritative standard reference. It would be difficult to find any volume including as much information. Recommended for the reference shelf of every high school science department.

An Introduction to Astronomy. Sixth Edition. Robert H. Baker. 364p. $6.95. D. Van Nostrand Company, Inc., 120 Alexander St., Princeton, N. J. 1960.
Written as a college textbook for a one-semester introductory course in astronomy, this work has something to offer teachers and advanced high school students. The sixth edition brings a standard work up to date with material from research on artificial satellites and other space probes. Attention is given to radio astronomy, and a new look at stellar evolution is provided.

Jenner and the Miracle of Vaccine. Edward F. Dolan, Jr. 242p. $3.50. Dodd, Mead and Company, 432 Fourth Ave., New York 16, N. Y. 1960.
The life story of Edward Jenner and his struggle against smallpox. The book has value for high school students because it provides an insight into the life and work of a great scientist. Recommended as supplementary reading for junior and senior high school students.

Animal Sounds and Communication. Edited by W. E. Lanyon and W. N. Tavolga. 444p. $9.50. American Institute of Biological Sciences, 2000 P St., N. W., Washington 6, D. C. 1961.
Price quoted includes book and 33⅓-rpm record with many animal sounds recorded. Would not have general appeal. However, would be useful to the high school biology teacher as reference and might be of some special interest to few members of his class. Book contains a number of pages presented in a symposium on animal sounds and communications. Groups of animals discussed include orthopterans, fish, amphibians, reptiles, and birds. Initial chapter on techniques for recording animal sounds would be helpful to the uninitiated. Record contains sounds referred to in the text. Two concluding chapters may prove especially useful to the high school biology teacher. These cover classification of animal sounds and a summary chapter which deals with many interesting characteristics and features of sounds produced by animals.

Educators Guide to Free Tapes, Scripts and Transcriptions. Seventh Edition. Compiled and edited by W. A. Wittich and G. H. Halsted. 204p. $5.75. Educators Progress Service, Randolph, Wis. 1961.
Latest in the series, this guide is similar to the free film listings by the same publisher. The 1961 edition contains titles of 129 tapes, 230 scripts, and 106 transcriptions. Publisher states that 155 of the 465 listings are new. The "Tape Adventurer" series from the previous guide is continued in this edition. Mate-

rials listed are primarily suited to the elementary grades. Although there is no section on science as such, 45 titles under Conservation-Natural Resources are included, as well as some other listings suitable for elementary school science. Grade levels are not indicated in the listings. The guide is indexed by title and subject and includes source information. Recommended as a worthwhile source.

The Story of Alchemy and Early Chemistry. John Maxson Stillman. 566p. $2.45. Dover Publications, Inc., 180 Varick St., New York 14, N. Y. 1960.

An effective book for those wishing a more complete knowledge of the developmental steps in the science of chemistry. Embraces the history of chemistry from ancient times before Christ to the end of the eighteenth century. Theories of the ancients along with biographies of early chemists are covered.

Matter and Antimatter. Maurice Duquesne. Translated from the French. 128p. $2.25. Harper and Brothers, 49 East 33rd St., New York 16, N. Y. 1960.

One of the Harper Science Today Series. Topics include: Atomic Theories, Relativity, Quantum Theory, Wave Mechanics, Dirac's Theory, Particle Accelerators and High Energy Physics, Anti-Nucleons, and others. Contains a concise treatment of the transition from classical to modern physics. The book traces briefly the evolution of atomic theories and devotes a suitable proportion of space to the great progress of the early twentieth century, the inexorable progress of the past fifty years, and the identification of anti-particles. A sprinkling of calculus notation is included. This is not casual reading, and the book is therefore recommended for the more advanced high school students.

How Things Grow. Herbert S. Zim. 64p. $2.50. William Morrow and Company, Inc., 425 Fourth Ave., New York 16, N. Y. 1960.

A well-written short work concerning growth by living plants and animals as well as growth of nonliving material. The emphasis is on the development of the human body. Each page carries black and white illustrations and simple charts and graphs to explain the text. Topics covered are: Growth by Accretion, Growth by Assimilation, Patterns of Growth, Human Embryology, Rates of Growth in Humans, Physical Growth Differences between Males and Females, Mental Growth, Emotional Growth, and Social Growth. This book could be easily read and understood by grades 4-7. Excellent supplement for health or general science classes.

The Story of the Atom. Mae and Ira Freeman. 82p. $1.95. Random House, Inc., 457 Madison Ave., New York 22, N. Y. 1960.

An Easy-to-Read Book. Chapter headings include: What Things Are Made Of, The Moving Molecules, Smaller Than Molecules,

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Six Days or Forever? Raymond Ginger. 224p. $3.95. The New American Library of World Literature, Inc., 501 Madison Ave., New York 22, N. Y. 1960.

The author has attempted to present a true picture of what actually happened at the famous court trial of "Tennessee *vs.* John Thomas Scopes." He describes how the proceedings were influenced by national, sectional, and state-wide forces. Considerable detail is given to William Jennings Bryan's part in the trial. The book should prove interesting reading for high school and college biology students.

The Plant Kingdom. Harold C. Bold. 114p. Paper, $1.50, cloth $2.95. Prentice-Hall, Inc., Englewood Cliffs, N. J. 1960.

This volume continues the excellent series in the Foundations of Modern Biology. It treats each group of plants completely in up-to-date discussions of classifications of forms. Line drawings and photographs illustrate the important features under consideration. The book should be on the reference shelf of every biology teacher and is recommended for the more advanced high school students as well.

Sea Within. William D. Snively. 150p. $3.95. J. B. Lippincott Company, East Washington Square, Philadelphia 5, Pa. 1960.

An interesting account of the blood and its importance. Much emphasis is given to the delicate chemical balance of the blood which is necessary for good health. Chemical necessities such as electrolyte balance, hormones, acid-base balance, and others are described, and the use of blood examination in disease diagnosis is explained. The book also outlines the development of the kidneys in man and their function in providing a proper osmotic balance in body fluids. Recommended for high school students in advanced biology or physiology classes.

Caves of Adventure. Haroun Tazieff. 222p. $1.45. The Viking Press, Inc., 625 Madison Ave., New York 22, N. Y. 1960.

The author tells the firsthand story of a famous French expedition into a labyrinth of caves two thousand feet underground in the Pyrenees. Not only can this book be read and enjoyed for entertainment, but it is also rich in authoritative information on the science of speleology. Contains sixteen pages of excellent photographs.

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"A Summer Chemistry Program for Teenagers." *Journal of Chemical Education,* 38:47. January 1961. A brief resume of an experimental summer class in chemistry, based on modern orbital theory, that was presented to 300 youths aged 11-17. The program was evaluated as well organized, short, informative, and practical. Excellent article for all science teachers who wish to assist in encouraging the thirst for scientific knowledge exhibited by this age group.

"Detection of Glycols in Crankcase Oils." *Materials: Research and Standards,* 1:30. January 1961. A well-written, informative chemistry experiment in substance separation dealing with a topic interesting to any teenager who ever owned or hoped to own a hot rod. Beneficial to science teachers in junior and senior high schools for the application of scientific principles to a practical, everyday situation.

"The Teaching of Physics in Schools." Report prepared for the Office of Scientific and Technical Personnel of the Organization for European Economic Cooperation. *Physics Today,* 14:30. January 1961. Physics is a vital part of our culture, and hence should be a part of the education of all children. With this as its thesis, the report outlines the changes in content that are necessary in the physics curriculum of the secondary schools. A general outline, based on fundamental concepts, is also given. In addition, recommendations are made relative to teaching techniques in physics.

"Current Teaching Practices and Problems in the General Physics Laboratory." By Haym Kruglak. *American Journal of Physics,* 28:791. December 1960.
In a recent survey conducted in 1000 institutions, the length of the period, instructional methods, evaluation techniques, and enrollments in college laboratory physics were investigated. The article describes the findings of the investigation.

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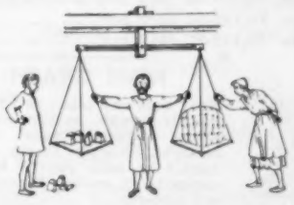

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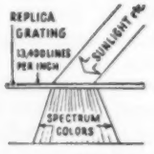

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Story of the Bloodstream. Part I: The Heart and Circulatory System. Charts, models, photomicrographs, and a photograph of the human heart are used to illustrate the circulatory system. Supplementing these devices are excellent photographs showing the action of valves in the human heart. Film describes the miracles of modern surgery whereby plastic valves are implanted. The action of the "heart pump" during surgery is shown. Recommended for high school and college biology classes. 29 min. Color $220. 1960. Moody Institute of Science, 11428 Santa Monica Blvd., Los Angeles 25, Calif.

Story of the Bloodstream. Part II: The Red Blood Cell. The film shows capillary circulation by means of magnification. The rapid transportation of blood is demonstrated by the use of a radioactive isotope. A molecular model illustrates the hemoglobin molecule. In addition, the function of hemoglobin in transporting oxygen is shown. Film describes how necessary information about gaseous infusion in a red blood cell is fed into an electronic computer. The shape of the cell is determined mathematically by the computer, and the result is shown on a plotted graph. For high school biology students. 24 min. Color $220. 1960. Moody Institute of Science, 11428 Santa Monica Blvd., Los Angeles 25, Calif.

Beyond the Speed of Sound. This is a descriptive film showing the behavior of supersonic air flow and how the problems of supersonic flight are being overcome by advance techniques in design. Grade level: upper high school and college. 19 min. Color. Available on loan basis with payment of return postage by user. 1960. Shell Oil Company Film Library, 160-07 Northern Blvd., Flushing 58, N. Y.

Myth, Superstition, and Science. Designed for elementary school students, this film attempts to examine myths and superstitions and test them against basic facts. A young girl and her "young scientist" brother are shown as real-life examples of people involved in some well-known superstitions. The film presents a strong, objective argument in favor of the systematic reasoning of scientists. Recommended for grades 4-7. 13 min. Color $135. 1960. International Film Bureau, Inc., 322 South Michigan Ave., Chicago 4, Ill.

Asteroids, Comets, and Meteorites. A good conception of the shapes, size, and orbits of asteroids are presented. Included is a discussion of how astronomers came to learn about asteroids, comets, and meteorites. Animation demonstrates the development of man's understanding of comets. Diagrams and photography illustrate the three objects in the film's title. The coverage of meteorites is particularly well done. Shown are methods of counting meteorites, the formation of heat by friction between air and a meteorite, and how meteorites are studied. Man-made satellites are included as the newest member of the solar system. Recommended for grades 7, 8, and 9. Color $110, B&W $60. 1960. Film Associates of California, 11014 Santa Monica Blvd., Los Angeles 25, Calif.

Science for Beginners. A series of six color filmstrips designed as an introduction to some of the fields of science. Titles are: *The World of Living Things,* 38 frames; *Our Home, the Earth,* 35 frames; *The Sky Above Our Earth,* 51 frames; *Machines and Tools To Help Us Work,* 40 frames; *Magnetism and Electricity,* 31 frames; and *Light, Heat, and Sound,* 31 frames. Each filmstrip suggests class activities. Although the strips are listed as "Science For Beginners," some concepts that are demonstrated obviously need background knowl-

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edge to be appreciated. Effective use depends on the ability of the teacher to add explanatory material. Under these conditions, the set would be a useful addition to the elementary school teacher's library of audio-visual materials. Color. Set of six $27; $5 each. 1960. Society For Visual Education, Inc., 1345 Diversey Parkway, Chicago 11, Ill.

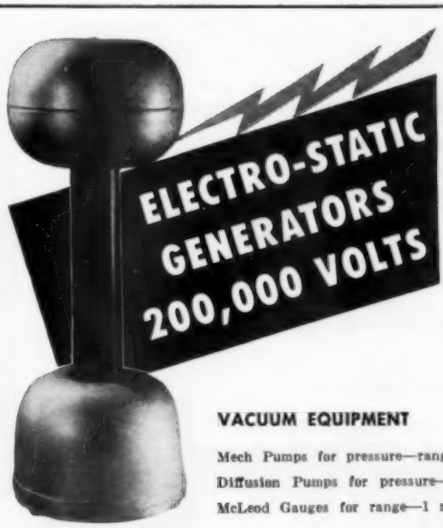
Introduction to Optics. An excellent work in the Physical Science Study Committee film series with a commentary by Dr. E. P. Little. Photography is excellent in sequences illustrating diffraction, scattering, refraction, and reflection. Much of the action involves actual techniques, experiments, and demonstrations that teachers could not duplicate in the classrooms. Some simple experiments and demonstrations are also included using items that are readily available. Recommended for high school physics classes. 23 min. Color $240. 1960. Modern Learning Aids, 3 East 54th St., New York 22, N. Y.

Pressure of Light. This film is narrated by Dr. Jerrold R. Zacharias of the Massachusetts Institute of Technology. Starting with the movement of a Crookes radiometer as related to light, Dr. Zacharias uses a thin foil suspended in a high vacuum to demonstrate how very small pressures from light will cause the foil to oscillate. The role of light pressure in the universe is also discussed. One of the Physical Science Study Committee film series. For advanced high school physics students. 21 min. Color $120. 1960. Modern Learning Aids, 3 East 54th St., New York 22, N. Y.

Life in the Woodlot. This is an excellent film on introductory ecology. Woven into the filmstrip is the story of an owner of a woodlot, who demonstrates his knowledge of seasonal and long-time changes in that area. The pyramid of relationships among man, plants, and animals is well developed through these steps: plants, insect grubs, fledgling grouse chick, snake hawk, and man. Competition among plants for photosynthesis is illustrated. The film shows the forest as an esthetic resource as well as a commercial one. For the alert biology teacher, this film would serve as a good teaching aid in the ecology of a hardwood forest. For the unit on conservation it would serve the purpose of stimulating an interest in ecological relationships and their foundations for good conservation practices. Film is recommended for high school biology classes and for use in instructing lay groups in many aspects of conservation. 17 min. Color $190, B&W $100. 1960. National Film Board of Canada, 680 Fifth Ave., New York 19, N. Y.

Life in the Sea. Four films in a series. Titles are: *Where Land and Water Meet, On the Rocks, Life on the Coral Reef,* and *Life Cycle.* The four together make an excellent ecological treatment designed for viewing by laymen. The titles are descriptive of the content. The first three describe areas, and the last develops the idea of the chain of life. All show excellent underwater photography of both plants and animals. Since films are intended for the layman or for the entertainment of biology classes, very few scientific terms are used. Probably the treatment is too general for use as a teaching aid. The commentator, for instance, consistently mispronounces the word "anemone." The films, however, would be useful to stimulate an interest in biology. 30 min each. Color $250 each, B&W $125 each. 1960. NET Film Service, Audio-Visual Center, Indiana University, Bloomington, Ind.

Crystals. An excellent work in the Physical Science Study Committee film series on the nature of crystals and their growth. Alan Holden of Bell Telephone Laboratories is



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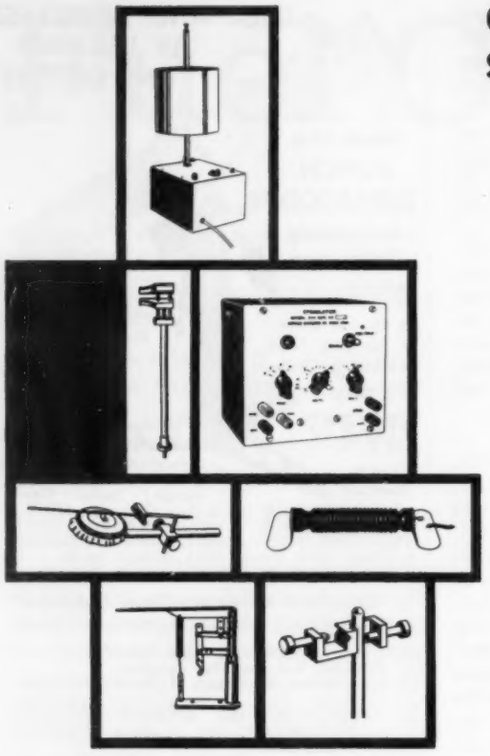

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The Eye. Science Motograph Chart No. 1239. A demonstration kit which can be used to show how the eye receives and reacts to light rays. Features include a special type of adhesive for holding labels to the chart, a movable device for demonstrating the focus of light rays in near- and farsightedness, and a concave and convex lens which can be placed on the chart to show how these eye defects may be corrected. The device does not show the binding of rays by the corrective lens, however. For elementary grades. $1.95 each (1-5); $1.75 (6 or more). Science Materials Center, 59 Fourth Ave., New York 3, N. Y.

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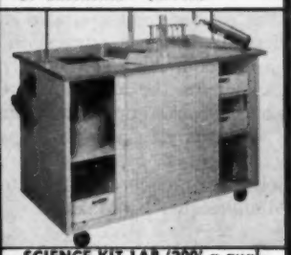

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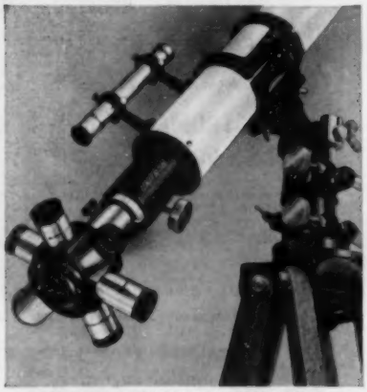

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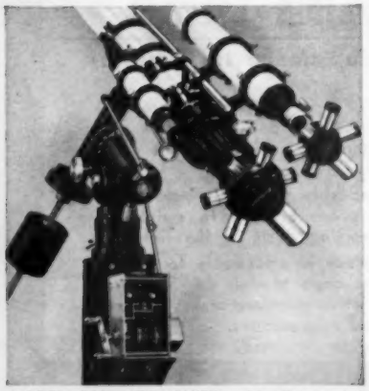

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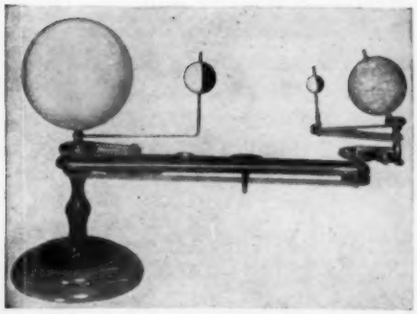

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Planning for Excellence in High School Science.

Developed by a conference on Selected Problems in Secondary School Science and prepared by Robert Stollberg and Theodore Benjamin. Shows place for and type of science teaching needed in the scientific and educational enterprises of today. 1961. 64p. $1.

Quality Science for Secondary Schools.

Suggestions for improving the science program and specific courses in junior and senior high schools with special reference to the continuous science program, kindergarten through twelfth grade. 1960. 210p. $3.

Selected Papers in Science Teaching.

Summarization is made of thirteen winning project entries from science teachers participating in the 1960 Science Teacher Achievement Recognition program. Projects include newly tested and improved activities of variety in teacher demonstrations, laboratory exercises, curricula recommendations, methods and techniques, and research work. 1960. 64p. $1.

Conference Reports: "Teacher Demonstrations in Chemistry"; "The Science Teacher as Career Counselor"; and "Teaching Critical Thinking Through Chemistry."

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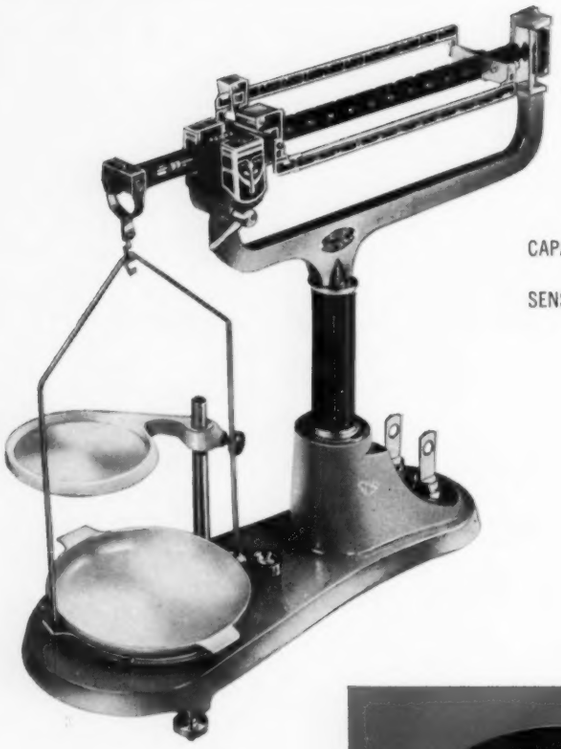

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